Fermi National Accelerator Laboratory

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# TESLA Test Cell Cryostat Support Post Thermal and Structural Analysis

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## INTRODUCTION

TeV Superconducting Linear Accelerator (TESLA) cryostats consist of eight, 1-meter-long radio frequency (RF) cavity modules cryogenically connected in series with one focusing quadrupole. Each module contains one, 9-cell superconducting RF cavity operating at 1.3 GHz in a 1.8K helium bath. Individual modules are self-contained in the sense that they have their own input couplers, high order mode couplers, and tuning mechanisms. Services common to the entire cryostat consist of 70K and 4.5K thermal radiation shields, shield supply and return lines, a 1.8K helium supply line, and a gas helium return pipe. All cavity modules, the quadrupole, and cryogenic services are contained in a single 12-meter-long vacuum vessel.

The goal of the present work on TESLA is the successful fabrication and test of four complete cryostat assemblies. These cryostats will be installed in a string, cooled to operating temperature, and powered. This test will address problems which may arise when modules are installed in a tunnel environment. It will also permit testing of the basic cooling concepts, measurement of static heat losses, and measurement of the RF performance of all cavities.[1]

All of the current design options utilize a post-type suspension system modeled after that developed for SSC collider dipoles. However, rather than a reentrant design like those in early SSC prototypes[2-5], this support uses a single filament wound composite tube. This latter design has recently been adopted for production SSC collider dipoles.[6]

Any successful design must be structurally adequate to meet the static and dynamic loads which occur during fabrication, shipping, installation, and operation. It must have low thermal conductivity to insulate the 1.8K helium volume from heat conducted from 300K and must be manufacturable at low cost. This report attempts to summarize the thermal and structural analysis leading to the selection of a candidate design for supports suitable for use in TESLA test cell cryostats.

## DESIGN OVERVIEW

There are two conceptual designs being discussed with respect to support post mounting. One uses supports located on top of the vacuum vessel such that the cold mass hangs from the support. The second uses supports located on the bottom of the vacuum vessel such that the cold mass rests on the support. This second concept is the more conventional of the two options, however, in principal there is no reason that hanging the cold mass from the support poses any inherent installation or reliability problems. The advantage to the hanging concept is that it provides a readily accessible place from which to gather direct alignment data when the complete cryostat is installed in the test string. There are two substantive disadvantages. First, a cryostat with top-mounted supports requires reinforcing rings around the vacuum vessel at each support location to support the weight of the hanging assembly. Second, it moves the cavity centerline further from the fixed support base making it more sensitive to displacements occurring due to cooldown and to the action of external forces, e.g. forces acting through the input coupler. These effects will be discussed later in this report. Figures 1 and 2 illustrate the differences between these two design options. The cross section shown is that currently being developed at DESY and INFN.

There are also two conceptual designs being discussed with respect to the number of supports. One uses three supports as a means by which to minimize the cost of support assemblies and the cost of the vacuum vessel and thermal radiation shields. The other uses four supports to minimize axial contraction during cooldown. These latter two conceptual design differences have little effect on the analysis presented here, but will be discussed in more detail later in this report.

## DESIGN ANALYSIS

There is little debate about the conceptual design of the support post itself. All of the design options being discussed utilize a single tube support developed as an alternative to the reentrant supports used in SSC collider dipole magnets.[2-6] The single tube support was developed primarily to reduce magnet cost.

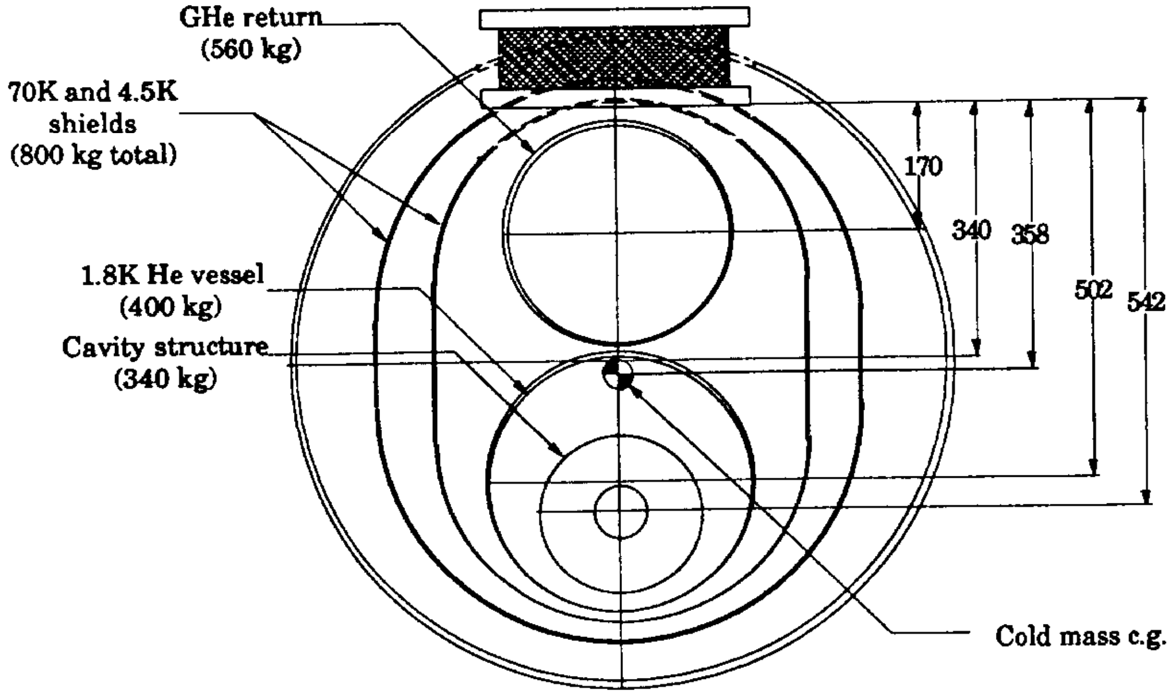


Figure 1. DESY Cross Section - Top Mounted Support

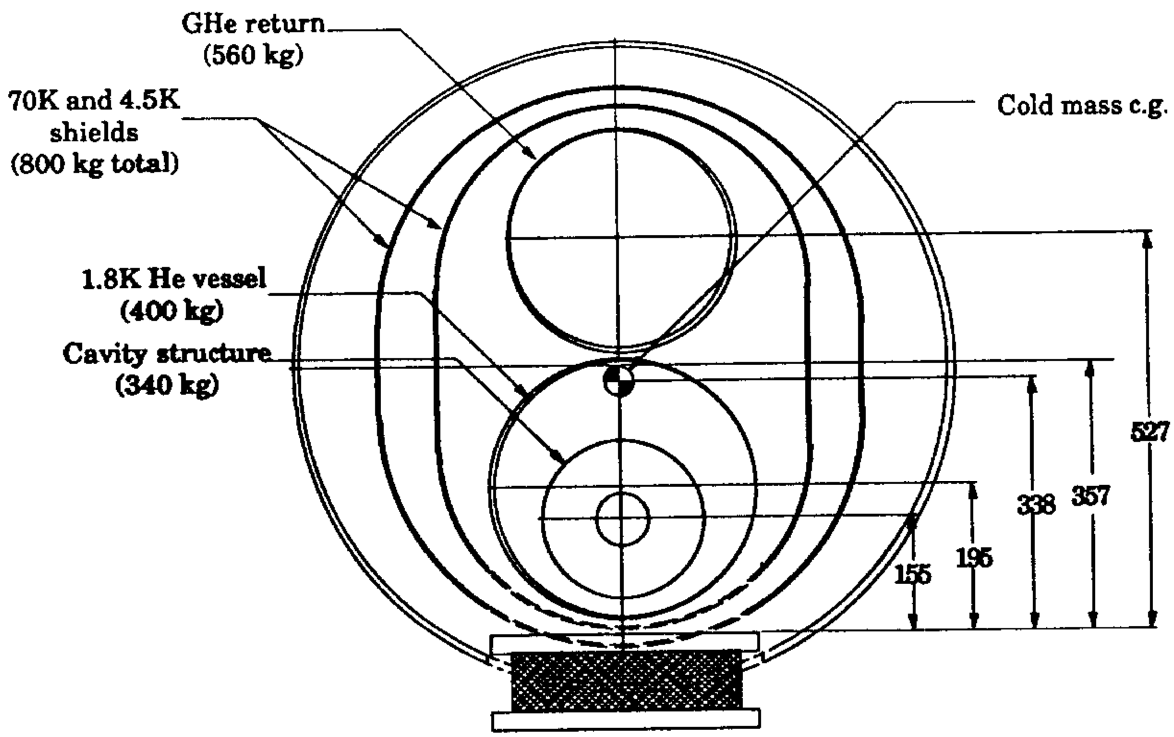


Figure 2. DESY Cross Section - Bottom Mounted Support

## Thermal Path Length Optimization

The design of a TESLA cryostat support begins with a thermal analysis to determine the relative position of the thermal intercepts. There are intercepts at 300K, 70K, 4.5K, and 1.8K. The 300K and 1.8K positions are fixed at the ends of each support. The 70K and 4.5K intercept locations may be chosen anywhere along the length of the support. Their position is dictated by constraints on the allowable static heat load. For this analysis it is assumed that the goal is to minimize the refrigeration power required at room temperature. The heat load at each thermal intercept is translated into a corresponding refrigeration requirement at room temperature by using an expression for the ideal work defined by Carnot and a realistic refrigerator efficiency. The Carnot efficiency is given by the following.

$$\text{Carnot efficiency} = T / (300 - T) \qquad [1]$$

where T is expressed in K.

Realistic refrigerator efficiencies are more difficult to estimate. Experiences at Fermilab, with the Tevatron refrigeration system, and at DESY, with the HERA system, indicate that reasonable refrigerator efficiencies are 20% at 70K and 4.5K and 10% at 1.8K. Combining these with the Carnot efficiencies results in the following room temperature loads. The results are expressed in watts per watt (W/W), e.g. 328 watts of power at room temperature are required to produce one watt of refrigeration at 4.5K.

**Table 1. Room Temperature Refrigeration Requirements**

| T | Carnot eff | Refrig eff | Combined eff | r.t. W/W |
|---|---|---|---|---|
| 70K | 30.43% | 20% | 6.09% | 16 |
| 4.5K | 1.52% | 20% | 0.30% | 328 |
| 1.8K | 0.60% | 10% | 0.06% | 1657 |

Figure 3 is a thermal model of a single tube support illustrating the pertinent analysis parameters. The optimal thermal path lengths (l) as fractions of the total support height are functions of the thermal intercept temperatures, material thermal conductivity, and tube cross sectional area (A). Ideally, there are thermal resistances at each intercept and at the cold mass connection. For the sake of this and subsequent analyses, these are assumed to be perfect connections. In reality, this assumption leads to a conservative result, i.e. actual heat loads, particularly to 1.8K are somewhat smaller than calculated values. The material assumed for the support is S-glass in an epoxy matrix. The thermal conductivity curve for this material is shown in figure 4. The dimension nomenclature and the results from this analysis are shown in figures 5 and 6 respectively.

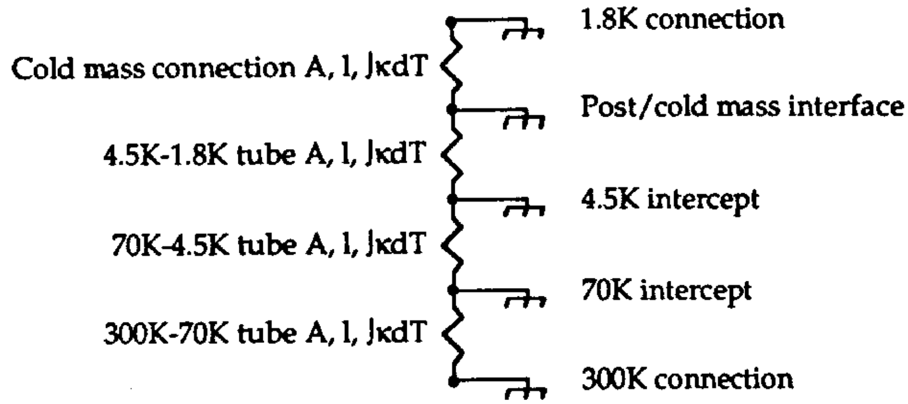


**Figure 3. Single Tube Support Thermal Model**

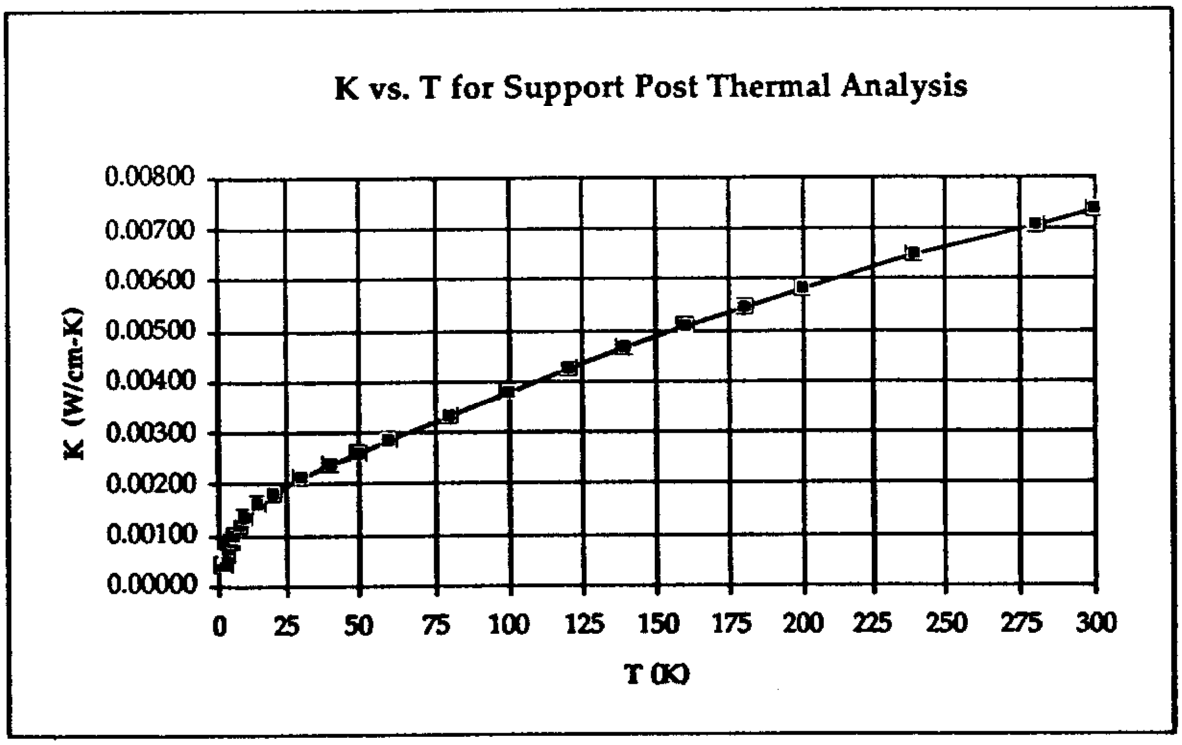


**Figure 4. Support Post Material Thermal Conductivity vs. Temperature**

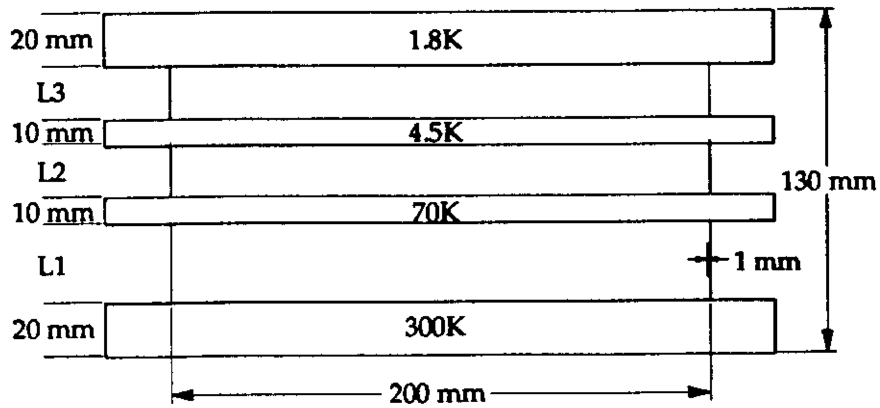


Figure 5. Thermal Path Length Analysis Support Dimension Nomenclature

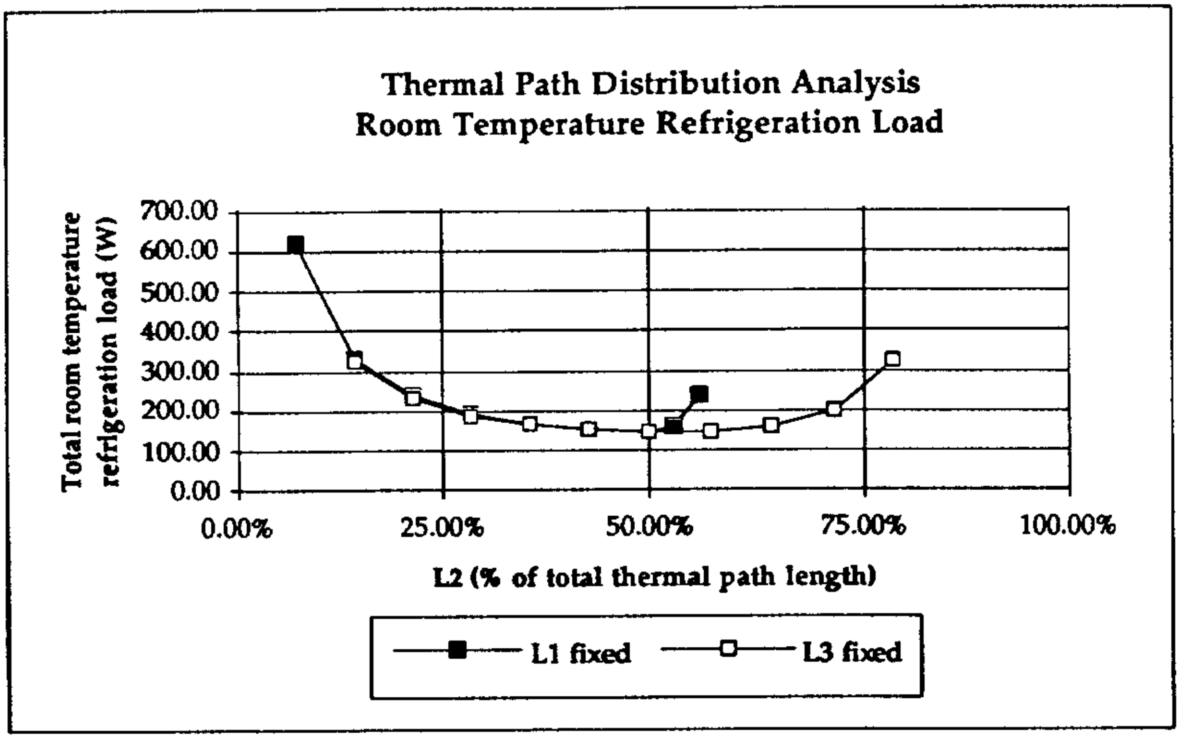


Figure 6. Thermal Path Length Analysis Results

Using figure 6, the minimum room temperature heat load occurs when L2, the 70K to 4.5K thermal path length, is 50% of the total thermal path length. This is the case when either L1 or L3 is held fixed. It is clear from figure 6 that the total room temperature heat load is rather insensitive to changes in L2 at its optimum, permitting relative freedom in positioning thermal intercepts as long as L2 is approximately 50% of the total thermal path length. This is especially true if L3 is fixed and only L1 and L2 are adjusted.

The path length optimization analysis also indicates that L3 should be as small as practical, approximately 5 mm for the support shown in figure 5. This is somewhat small when fabrication of the supports and subsequent assembly into the cryostat are considered. For mechanical attachment considerations, subsequent analyses will use 10 mm for L3, the thermal path length between 4.5K and 1.8K.

### Detailed Thermal and Structural Analysis

The thermal path length optimization defines the position of thermal intercepts along the length of the support without regard for specified heat loads or structural requirements. The analysis of an actual support structure must consider the thermal and structural load constraints simultaneously. These are generally at odds with one another, that is low heat load implies low strength while high structural strength implies increased heat load. The budgeted heat loads and structural constraints are given in tables 2 and 3 respectively.[1]

**Table 2. Budgeted Heat Loads per Meter of Cryostat Length (W/m)**

| 70K | 4.5K | 1.8K |
|---|---|---|
| 0.5 | 0.2 | 0.05 |

**Table 3. Structural Load Constraints**

| Load Direction | Load |
|---|---|
| Vertical | 1.0 g |
| Lateral | 1.0 g |
| Axial | 1.8 g |

Given the room temperature heat load conversions in table 1 and the budgeted heat loads in table 2, an equivalent room temperature heat load budget may be defined by the following.

$$Q_{r.t.} = (0.5 \times 16) + (0.2 \times 328) + (0.05 \times 1657) = 156.45 \text{ W/m} \quad [2]$$

For a 12 meter long cryostat, this results in the following allowable heat loads per support.

Table 4. Budgeted Heat Loads per Support (W)

| # of supports | 70K | 4.5K | 1.8K | r.t. equivalent |
|---|---|---|---|---|
| 3 | 2.00 | 0.80 | 0.20 | 626 |
| 4 | 1.50 | 0.60 | 0.15 | 469 |

The weights of all cold mass components are given in figures 1 and 2. These weights are estimated and include the GHe return pipe (560 kg), 70K and 4.5K shields (800 kg), 1.8K He vessels (400 kg), and RF cavity structures (340 kg). Weights for small components are included in the totals for each sub-system. There is an additional, estimated 140 kg quadrupole at one end of the cryostat assemble. The entire suspended cold mass weight is therefore 2240 kg. It is sufficiently accurate for the sake of this analysis to assume the weight is uniformly distributed among all supports. For the three and four support options, this results in the following lateral load per support.

Table 5. Lateral Loads per Support (kg)

| # of supports | Lateral load (kg) |
|---|---|
| 3 | 746.7 |
| 4 | 560.0 |

Using figures 1 and 2, the center of gravity of the cold mass assembly is nearly equidistant from the 1.8K surface of the post in both cases, 358 mm in the case of the top mounted support and 338 mm in the bottom mounted case. At this point in the design, there is enough uncertainty in the weights and final geometry to allow us to treat them as equal.

A physical envelope to limit the scope of the optimization study was chosen for the support post structure. Figure 7 illustrates the nomenclature used in the support post structural and thermal analysis. Table 6 lists all of the parameters and constraints used to define the dimensions for any particular analysis iteration. Note that the 70K to 4.5K thermal path length (LThrm2) is half the total thermal path length to minimize the room temperature heat load per the path length analysis above. The analysis program is capable of optimizing the wall thickness of each tube section, i.e. T1, T2, and T3 in figure 7. Ideally the tube can be machined with different thicknesses to take advantage of the decreasing bending stress along the support length. However, this has little effect on heat loads and decreases the lateral natural frequency of the support. Uniform wall thicknesses are assumed here to minimize machining cost on the complete assembly.

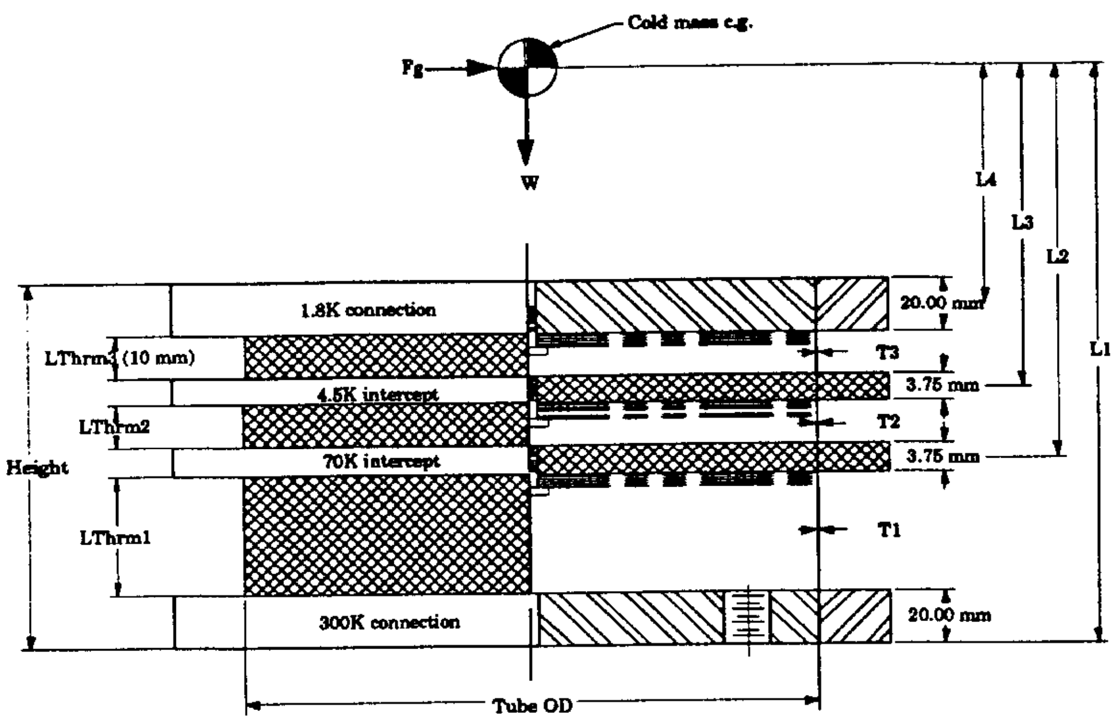


Figure 7. Support Analysis Nomenclature

Table 6. Support Post Dimensional Parameters and Constraints

| | |
|---|---|
| Overall height range | 100 mm - 250 mm |
| Outside diameter range | 150 mm - 300 mm |
| Wall thickness | Uniform to satisfy strength, safety factor = 2 |
| 300K and 1.8K flange thkns | 20 mm |
| 70K and 4.5K intercept thkns | 10 mm |
| LThrm1 (300K-70K path len) | Height - 60 mm - LThrm2 - LThrm3 |
| LThrm2 (70K-4.5K path len) | (Height - 60 mm) / 2 |
| LThrm3 (4.5K-1.8K path len) | 10 mm |
| L1 | Height + 348 mm |
| L2 | L1 - LThrm1 - 30 mm |
| L3 | L2 - LThrm2 - 20 mm |
| L4 | 358 mm |
| Fg (lateral c.g. force) | 746.7 kg (3 supports), 560.0 kg (4 supports) |
| W | -Fg |

Table 7 lists the applicable thermal and structural properties for the composite material assumed for these analyses.

**Table 7. Support Post Material Thermal and Structural Properties**

| | |
|---|---|
| $\int KdT$ (300K-70K) | 1.249 W/cm |
| $\int KdT$ (70K-4.5K) | 0.146 W/cm |
| $\int KdT$ (4.5K-1.8K) | 0.0015 W/cm |
| E (Young's modulus) | 27.58 GPa |
| n (Poisson's ratio) | 0.2 |
| G (Shear modulus) | 2.62 GPa |
| $s_{ult}$ (ultimate tensile and compressive strength) | 275.8 MPa |
| $t_{ult}$ (ultimate shear strength) | 137.9 MPa |

## Thermal and Structural Analysis Results

Analyses were performed over the height and diameter ranges listed in table 6. The complete results for these analyses are shown in appendix A, table A-1 and figures A-1 through A-5 for the case of a cryostat with 3 supports and appendix B, table B-1 and figures B-1 through B-5 for the case using 4 supports. The analysis yields tube stresses, heat loads to 70K, 4.5K, and 1.8K, the equivalent room temperature refrigeration power required to meet these heat loads, the cold mass lateral deflection when subject to the lateral load (Fg), and an estimate of the lateral resonant frequency. Although not explicitly specified in the design requirements it is thought that the support resonant frequency should be above 10 Hz and below 25 Hz to minimize susceptibility to ground motion and electrically induced vibrations (50 Hz power) respectively. For this analysis a 12.5 to 18.75 Hz band has been defined within which the calculated resonance should fall. These values are 25% above and below the 10 Hz and 25 Hz limits respectively.

From tables A-1 and B-1 a total of five supports satisfy all of the above criteria, i.e. 70K, 4.5K, and 1.8K heat loads, structural constraints, and the constraint on resonant frequency. These are summarized in table 8 and shown in tables A-1 and B-1 in shaded, bold type.

Several things become clear when looking at the results shown in these tables and figures. The supports which satisfy all of the criteria outlined here tend to be larger than those in previous conceptual designs. Typical diameters have varied between 200 and 300 mm. Heights have varied between 100 and 190 mm. The larger diameters here are required to meet the proposed resonant frequency constraint. The greater heights are required to meet the heat load budget, given the increased diameters. Tube stresses are typically well below the allowable (defined as the ultimate strength derated by a safety factor of two). This is due to the fact that the governing structural criteria is elastic stability, i.e.

the tubes are sized to prevent local buckling of the material which occurs at stresses well below that causing tensile or compressive failure.[3,4]

Table 8. Analysis Summary of Candidate Supports
(see appendices A and B for details)
(heat loads are per support)

| # of supports | Height (mm) | Diameter (mm) | Q70 (W) | Q4.5 (W) | Q1.8 (W) | Q r.t. (W) | Nat freq (Hz) |
|---|---|---|---|---|---|---|---|
| 3 | 220 | 275 | 1.96 | 0.20 | 0.02 | 130 | 12.5 |
| 3 | 230 | 300 | 1.93 | 0.20 | 0.02 | 130 | 12.9 |
| 3 | 240 | 300 | 1.82 | 0.19 | 0.02 | 125 | 12.6 |
| 4 | 240 | 275 | 1.50 | 0.16 | 0.02 | 103 | 12.6 |
| 4 | 250 | 300 | 1.49 | 0.16 | 0.02 | 105 | 13.1 |

These results also indicate that the specified heat loads to 70K, 4.5K, and 1.8K are not consistent with minimizing the room temperature heat load. For example, for the first entry in table 8, the calculated heat loads which meet the 70K, 4.5K, and 1.8K specifications and minimize room temperature heat load are 1.96 W to 70K, 0.20 W to 4.5K, and 0.02 W to 1.8K resulting in a room temperature load of 130 W, nearly a factor of five below the value listed in table 4. If minimized room temperature heat load is, in fact, a viable specification, it would help the design process to broaden the range of individual thermal station heat loads. One could then, for example, look for a design solution that results in a resonant frequency more toward the middle of the 12.5 to 18.75 Hz band, or define a stiffness specification in some other way. All of the cases presented in appendices A and B have room temperature heat loads below the budget shown in table 4, some with 70K heat loads five times the 70K budget.

As an example, suppose that, rather than the absolute limits on the 70K, 4.5K, and 1.8K heat loads in table 2, the specification were rewritten as shown in table 9.

Table 9. Alternate Specification for Budgeted Heat Loads
per Meter of Cryostat Length (W/m)

| 70K | 4.5K | 1.8K |
|---|---|---|
| < 1.0 | < 0.25 | < 0.025 |

This results in a new set of specifications for the heat load per support shown in table 10.

**Table 10. Budgeted Heat Loads per Support (W)**
**Using Alternate Specification in Table 9**

| # of supports | 70K | 4.5K | 1.8K | r.t. equivalent |
|---|---|---|---|---|
| 3 | < 4.00 | < 1.00 | < 0.10 | 558 max |
| 4 | < 3.00 | < 0.75 | < 0.075 | 418 max |

Even with all the above heat loads at their upper limit, the room temperature load is less than that given by equation [2] and listed in table 4. What this alternate specification does, however, is open up much of tables A-1 and B-1 for the selection of suitable support alternatives.

**Top vs. Bottom Mounted Supports**

As stated in the introduction to this report, there are no inherent difficulties with either top or bottom mounted supports from the standpoint of assembly or long term stability. Each has its merits and its drawbacks. There is however, one substantial difference, and that is in the deflection of the cavity centerline when subjected to external forces. Forces will act on the beam tube during cooldown by virtue of support from the gas helium tube and from thermal contraction which occurs in the input coupler. Although the magnitude is unknown, some relative differences can be calculated for each option. Figure 8 illustrates the beam tube centerline deflection for the support case highlighted in table A-1, page 3, and the cryostat dimensions in figures 1 and 2. Due to the distance the cavity lies from the support post base, the beam tube deflection in the top mounted case is more than a factor of two greater than in the bottom mounted case. Given the tight alignment tolerances required in the final installation, it seems that the design should strive for any alternatives which increase stiffness and thereby minimize deflections under the influence of outside forces.

**SUMMARY**

The analysis presented here is meant as a guide to the design of TESLA test cell cryostat supports. As in any complex device, there are many factors to be considered. Hopefully, most have been covered here, but some have been mentioned only briefly, e.g. alignment, cost, reliability, and ease of manufacture. Using criteria discussed throughout this report, a few conclusions can be drawn.

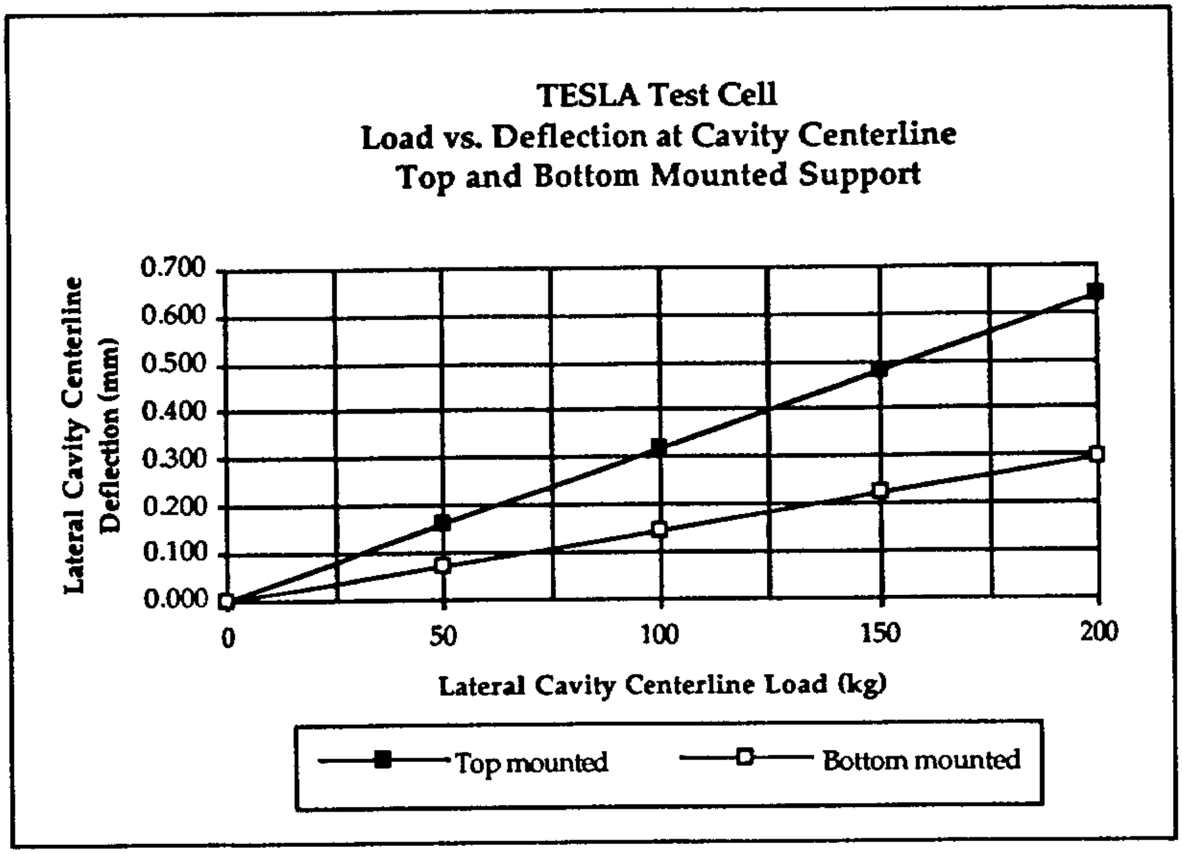


Figure 8. Load vs. Deflection for Top and Bottom Mounted Supports

First, assuming that minimizing the room temperature heat load is a viable basis for design development, the original heat load budgets to 70K, 4.5K, and 1.8K might warrant revision. Second, a firm specification on the suspension system lateral stiffness would be a useful means by which to assure a good overall design, not just one which meets the heat load budget. Third, thermally and structurally, there is no significant advantage to a cryostat using three or four supports. This is not surprising due to the fact that the structural and thermal analyses are largely linear. Cost and thermal contraction issues will likely play more significant roles in this choice. Finally, although potentially more practical in the alignment process, top mounted supports are probably not the best choice if one hopes to minimize lateral deflections of the cavity beam line during cooldown, alignment, and other operations which may subject the cavity or helium vessel to external forces.

The goal of this report has been to focus on issues critical to the development of a suspension system which addresses all of the pertinent design issues. Hopefully, it can serve as a guide for continued suspension system development and be useful as a tool to select or discount various conceptual design options.

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# APPENDIX A

## Thermal and Structural Analysis Results
## 3 Supports per Cryostat

Date: 8/13/92 Time: 8:22 Filename: Support analysis cases (si)

**TESLA Test Cell Support Analysis**
**3 supports per cryostat**
**T.Nicol - Fermilab - August 1992**

| Refrigeration system W@r.t. to W@T | | |
|---|---|---|
| T (K) | eff | W/W |
| 70 | 20% | 16 |
| 4.5 | 20% | 328 |
| 1.8 | 10% | 1657 |

| Heat load budget/suppt | | |
|---|---|---|
| T (K) | Q (W) | Q r.t. (W) |
| 70 | 2.00 | 33 |
| 4.5 | 0.80 | 263 |
| 1.8 | 0.20 | 331 |

| Data for plotting budget values (per support) | | | | | | |
|---|---|---|---|---|---|---|
| Ht (mm) | Q70 (W) | Q4.5 (W) | Q1.8 (W) | Q r.t (W) | Nat f (Hz) | Nat f (Hz) |
| 100 | 2.00 | 0.80 | 0.20 | 627 | 12.50 | 18.75 |
| 250 | 2.00 | 0.80 | 0.20 | 627 | 12.50 | 18.75 |

| Ht (mm) | OD (mm) | L1 (mm) | L2 (mm) | L3 (mm) | L4 (mm) | LTh1 (mm) | LTh2 (mm) | LTh3 (mm) | T1 (mm) | T2 (mm) | T3 (mm) | Sig1 (MPa) | Sig2 (MPa) | Sig3 (MPa) | Q70 (W) | Q4.5 (W) | Q1.8 (W) | Q r.t. (W) | Fg (kg) | dx (mm) | Nat f (Hz) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 150.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.702 | 1.702 | 1.702 | 122.4 | 113.5 | 106.0 | 9.285 | 0.563 | 0.012 | 357.4 | 746.6 | 1.135 | 14.8 |
| 110.0 | 150.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.702 | 1.702 | 1.702 | 123.6 | 113.6 | 104.9 | 6.176 | 0.453 | 0.012 | 270.4 | 746.6 | 1.420 | 13.2 |
| 120.0 | 150.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.727 | 1.727 | 1.727 | 124.9 | 113.8 | 103.9 | 4.640 | 0.379 | 0.012 | 221.0 | 746.6 | 1.709 | 12.1 |
| 130.0 | 150.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.753 | 1.753 | 1.753 | 126.2 | 113.9 | 102.9 | 3.726 | 0.327 | 0.012 | 189.0 | 746.6 | 2.002 | 11.1 |
| 140.0 | 150.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.753 | 1.753 | 1.753 | 127.4 | 114.0 | 101.9 | 3.121 | 0.287 | 0.013 | 166.3 | 746.6 | 2.299 | 10.4 |
| 150.0 | 150.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.778 | 1.778 | 1.778 | 128.6 | 114.2 | 101.0 | 2.691 | 0.256 | 0.013 | 149.2 | 746.6 | 2.601 | 9.8 |
| 160.0 | 150.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.803 | 1.803 | 1.803 | 129.9 | 114.4 | 100.0 | 2.370 | 0.231 | 0.013 | 136.1 | 746.6 | 2.908 | 9.2 |
| 170.0 | 150.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.803 | 1.803 | 1.803 | 131.1 | 114.5 | 99.2 | 2.121 | 0.211 | 0.013 | 125.6 | 746.6 | 3.221 | 8.8 |
| 180.0 | 150.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.829 | 1.829 | 1.829 | 132.3 | 114.7 | 98.3 | 1.922 | 0.194 | 0.013 | 116.8 | 746.6 | 3.538 | 8.4 |
| 190.0 | 150.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.854 | 1.854 | 1.854 | 133.4 | 114.9 | 97.4 | 1.760 | 0.180 | 0.013 | 109.5 | 746.6 | 3.861 | 8.0 |
| 200.0 | 150.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.854 | 1.854 | 1.854 | 134.6 | 115.0 | 96.6 | 1.625 | 0.168 | 0.013 | 103.6 | 746.6 | 4.191 | 7.7 |
| 210.0 | 150.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.880 | 1.880 | 1.880 | 135.8 | 115.2 | 95.8 | 1.511 | 0.157 | 0.013 | 98.3 | 746.6 | 4.526 | 7.4 |
| 220.0 | 150.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.905 | 1.905 | 1.905 | 136.9 | 115.4 | 95.0 | 1.414 | 0.147 | 0.013 | 93.7 | 746.6 | 4.867 | 7.1 |
| 230.0 | 150.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.905 | 1.905 | 1.905 | 137.9 | 115.5 | 94.1 | 1.331 | 0.139 | 0.014 | 89.9 | 746.6 | 5.204 | 6.9 |
| 240.0 | 150.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.956 | 1.956 | 1.956 | 137.9 | 114.7 | 92.6 | 1.268 | 0.133 | 0.014 | 87.2 | 746.6 | 5.512 | 6.7 |
| 250.0 | 150.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.981 | 1.981 | 1.981 | 137.9 | 114.0 | 91.2 | 1.212 | 0.127 | 0.014 | 84.7 | 746.6 | 5.822 | 6.5 |
| 100.0 | 175.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.575 | 1.575 | 1.575 | 97.4 | 90.5 | 84.5 | 10.082 | 0.612 | 0.013 | 388.1 | 746.6 | 0.841 | 17.2 |
| 110.0 | 175.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.600 | 1.600 | 1.600 | 98.4 | 90.5 | 83.7 | 6.706 | 0.492 | 0.013 | 293.5 | 746.6 | 1.049 | 15.4 |
| 120.0 | 175.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.600 | 1.600 | 1.600 | 99.4 | 90.6 | 82.9 | 5.037 | 0.412 | 0.013 | 239.9 | 746.6 | 1.262 | 14.0 |
| 130.0 | 175.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.626 | 1.626 | 1.626 | 100.4 | 90.7 | 82.1 | 4.045 | 0.355 | 0.013 | 204.9 | 746.6 | 1.478 | 13.0 |
| 140.0 | 175.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.626 | 1.626 | 1.626 | 101.3 | 90.8 | 81.3 | 3.387 | 0.311 | 0.014 | 180.3 | 746.6 | 1.697 | 12.1 |
| 150.0 | 175.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.651 | 1.651 | 1.651 | 102.3 | 91.0 | 80.6 | 2.920 | 0.278 | 0.014 | 161.9 | 746.6 | 1.915 | 11.4 |
| 160.0 | 175.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.676 | 1.676 | 1.676 | 103.3 | 91.1 | 79.8 | 2.572 | 0.251 | 0.014 | 147.4 | 746.6 | 2.139 | 10.8 |
| 170.0 | 175.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.676 | 1.676 | 1.676 | 104.2 | 91.2 | 79.1 | 2.301 | 0.229 | 0.014 | 136.0 | 746.6 | 2.367 | 10.2 |
| 180.0 | 175.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.702 | 1.702 | 1.702 | 105.1 | 91.3 | 78.4 | 2.085 | 0.211 | 0.014 | 126.7 | 746.6 | 2.596 | 9.8 |
| 190.0 | 175.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.702 | 1.702 | 1.702 | 106.1 | 91.5 | 77.8 | 1.909 | 0.195 | 0.014 | 118.8 | 746.6 | 2.830 | 9.4 |
| 200.0 | 175.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.727 | 1.727 | 1.727 | 107.0 | 91.6 | 77.1 | 1.763 | 0.182 | 0.014 | 112.3 | 746.6 | 3.066 | 9.0 |
| 210.0 | 175.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.753 | 1.753 | 1.753 | 107.9 | 91.7 | 76.5 | 1.639 | 0.170 | 0.015 | 106.7 | 746.6 | 3.307 | 8.7 |
| 220.0 | 175.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.753 | 1.753 | 1.753 | 108.8 | 91.9 | 75.9 | 1.533 | 0.160 | 0.015 | 101.7 | 746.6 | 3.551 | 8.4 |
| 230.0 | 175.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.778 | 1.778 | 1.778 | 109.7 | 92.0 | 75.3 | 1.441 | 0.151 | 0.015 | 97.2 | 746.6 | 3.800 | 8.1 |
| 240.0 | 175.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.778 | 1.778 | 1.778 | 110.6 | 92.2 | 74.7 | 1.361 | 0.143 | 0.015 | 93.6 | 746.6 | 4.054 | 7.8 |
| 250.0 | 175.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.803 | 1.803 | 1.803 | 111.5 | 92.4 | 74.1 | 1.290 | 0.136 | 0.015 | 90.4 | 746.6 | 4.310 | 7.6 |

Table A-1: page 1

Date: 8/13/92 Time: 8:22 Filename: Support analysis cases (si)

| Ht | OD | L1 | L2 | L3 | L4 | LTh1 | LTh2 | LTh3 | T1 | T2 | T3 | Sig1 | Sig2 | Sig3 | Q70 | Q4.5 | QLB | Q r.t. | Fg | dx | Nat f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (MPa) | (MPa) | (MPa) | (W) | (W) | (W) | (W) | (kg) | (mm) | (Hz) |
| 100.0 | 200.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.473 | 1.473 | 1.473 | 80.0 | 74.4 | 69.6 | 10.839 | 0.658 | 0.014 | 417.3 | 746.6 | 0.660 | 19.4 |
| 110.0 | 200.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.499 | 1.499 | 1.499 | 80.8 | 74.5 | 68.9 | 7.208 | 0.529 | 0.014 | 315.3 | 746.6 | 0.823 | 17.4 |
| 120.0 | 200.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.499 | 1.499 | 1.499 | 81.6 | 74.5 | 68.2 | 5.413 | 0.442 | 0.014 | 257.9 | 746.6 | 0.991 | 15.9 |
| 130.0 | 200.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.524 | 1.524 | 1.524 | 82.4 | 74.6 | 67.6 | 4.346 | 0.381 | 0.015 | 220.4 | 746.6 | 1.156 | 14.7 |
| 140.0 | 200.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.524 | 1.524 | 1.524 | 83.2 | 74.7 | 67.0 | 3.640 | 0.335 | 0.015 | 193.7 | 746.6 | 1.326 | 13.7 |
| 150.0 | 200.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.549 | 1.549 | 1.549 | 84.0 | 74.8 | 66.4 | 3.137 | 0.299 | 0.015 | 173.9 | 746.6 | 1.496 | 12.9 |
| 160.0 | 200.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.575 | 1.575 | 1.575 | 84.8 | 74.9 | 65.8 | 2.762 | 0.270 | 0.015 | 158.6 | 746.6 | 1.669 | 12.2 |
| 170.0 | 200.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.575 | 1.575 | 1.575 | 85.5 | 75.0 | 65.2 | 2.472 | 0.246 | 0.015 | 146.1 | 746.6 | 1.844 | 11.6 |
| 180.0 | 200.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.600 | 1.600 | 1.600 | 86.3 | 75.1 | 64.6 | 2.240 | 0.226 | 0.015 | 136.1 | 746.6 | 2.019 | 11.1 |
| 190.0 | 200.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.600 | 1.600 | 1.600 | 87.1 | 75.2 | 64.1 | 2.050 | 0.209 | 0.015 | 127.8 | 746.6 | 2.197 | 10.6 |
| 200.0 | 200.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.626 | 1.626 | 1.626 | 87.8 | 75.3 | 63.5 | 1.893 | 0.195 | 0.015 | 120.5 | 746.6 | 2.380 | 10.2 |
| 210.0 | 200.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.626 | 1.626 | 1.626 | 88.5 | 75.4 | 63.0 | 1.760 | 0.183 | 0.016 | 114.5 | 746.6 | 2.563 | 9.8 |
| 220.0 | 200.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.651 | 1.651 | 1.651 | 89.3 | 75.5 | 62.5 | 1.646 | 0.171 | 0.016 | 109.3 | 746.6 | 2.748 | 9.5 |
| 230.0 | 200.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.651 | 1.651 | 1.651 | 90.0 | 75.7 | 62.0 | 1.547 | 0.162 | 0.016 | 104.6 | 746.6 | 2.936 | 9.2 |
| 240.0 | 200.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.676 | 1.676 | 1.676 | 90.7 | 75.8 | 61.5 | 1.460 | 0.153 | 0.016 | 100.3 | 746.6 | 3.129 | 8.9 |
| 250.0 | 200.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.676 | 1.676 | 1.676 | 91.5 | 75.9 | 61.1 | 1.384 | 0.145 | 0.016 | 97.1 | 746.6 | 3.322 | 8.7 |
| 100.0 | 225.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.397 | 1.397 | 1.397 | 67.4 | 62.7 | 58.7 | 11.562 | 0.702 | 0.015 | 445.0 | 746.6 | 0.541 | 21.4 |
| 110.0 | 225.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.422 | 1.422 | 1.422 | 68.1 | 62.7 | 58.1 | 7.688 | 0.564 | 0.015 | 336.4 | 746.6 | 0.676 | 19.2 |
| 120.0 | 225.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.422 | 1.422 | 1.422 | 68.7 | 62.8 | 57.6 | 5.773 | 0.472 | 0.015 | 275.1 | 746.6 | 0.810 | 17.5 |
| 130.0 | 225.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.448 | 1.448 | 1.448 | 69.4 | 62.9 | 57.0 | 4.635 | 0.406 | 0.015 | 234.8 | 746.6 | 0.945 | 16.2 |
| 140.0 | 225.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.448 | 1.448 | 1.448 | 70.0 | 62.9 | 56.5 | 3.881 | 0.357 | 0.016 | 206.5 | 746.6 | 1.082 | 15.2 |
| 150.0 | 225.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.473 | 1.473 | 1.473 | 70.7 | 63.0 | 56.0 | 3.345 | 0.318 | 0.016 | 185.4 | 746.6 | 1.219 | 14.3 |
| 160.0 | 225.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.473 | 1.473 | 1.473 | 71.3 | 63.1 | 55.5 | 2.945 | 0.288 | 0.016 | 168.8 | 746.6 | 1.359 | 13.5 |
| 170.0 | 225.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.499 | 1.499 | 1.499 | 72.0 | 63.2 | 55.0 | 2.634 | 0.262 | 0.016 | 156.0 | 746.6 | 1.499 | 12.9 |
| 180.0 | 225.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.499 | 1.499 | 1.499 | 72.6 | 63.3 | 54.5 | 2.387 | 0.241 | 0.016 | 145.0 | 746.6 | 1.641 | 12.3 |
| 190.0 | 225.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.524 | 1.524 | 1.524 | 73.2 | 63.3 | 54.1 | 2.185 | 0.223 | 0.016 | 135.9 | 746.6 | 1.783 | 11.8 |
| 200.0 | 225.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.524 | 1.524 | 1.524 | 73.8 | 63.4 | 53.6 | 2.017 | 0.208 | 0.017 | 128.7 | 746.6 | 1.928 | 11.4 |
| 210.0 | 225.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.549 | 1.549 | 1.549 | 74.4 | 63.5 | 53.2 | 1.875 | 0.195 | 0.017 | 122.0 | 746.6 | 2.075 | 10.9 |
| 220.0 | 225.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.549 | 1.549 | 1.549 | 75.1 | 63.6 | 52.8 | 1.753 | 0.183 | 0.017 | 116.2 | 746.6 | 2.223 | 10.6 |
| 230.0 | 225.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.575 | 1.575 | 1.575 | 75.7 | 63.7 | 52.4 | 1.648 | 0.172 | 0.017 | 111.6 | 746.6 | 2.372 | 10.2 |
| 240.0 | 225.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.575 | 1.575 | 1.575 | 76.3 | 63.8 | 52.0 | 1.556 | 0.163 | 0.017 | 107.1 | 746.6 | 2.522 | 9.9 |
| 250.0 | 225.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.600 | 1.600 | 1.600 | 76.9 | 63.9 | 51.6 | 1.474 | 0.155 | 0.017 | 103.1 | 746.6 | 2.675 | 9.6 |

Date: 8/13/92 Time: 8:22 Filename: Support analysis cases (sl)

| Ht | OD | L1 | L2 | L3 | L4 | [illegible] | [illegible] | [illegible] | T1 | T2 | T3 | Sig1 | Sig2 | Sig3 | Q70 | Q4.8 | Q1.8 | Q r.t. | Fg | dx | Nat f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (MPa) | (MPa) | (MPa) | (W) | (W) | (W) | (W) | (kg) | (mm) | (Hz) |
| 100.0 | 250.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.346 | 1.346 | 1.346 | 57.8 | 53.8 | 50.4 | 12.258 | 0.744 | 0.016 | 471.6 | 746.6 | 0.457 | 23.3 |
| 110.0 | 250.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.346 | 1.346 | 1.346 | 58.4 | 53.9 | 50.0 | 8.150 | 0.598 | 0.016 | 356.7 | 746.6 | 0.572 | 20.9 |
| 120.0 | 250.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.372 | 1.372 | 1.372 | 58.9 | 53.9 | 49.5 | 6.119 | 0.500 | 0.016 | 291.4 | 746.6 | 0.686 | 19.1 |
| 130.0 | 250.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.372 | 1.372 | 1.372 | 59.5 | 54.0 | 49.0 | 4.912 | 0.430 | 0.016 | 249.0 | 746.6 | 0.798 | 17.6 |
| 140.0 | 250.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.397 | 1.397 | 1.397 | 60.1 | 54.0 | 48.6 | 4.112 | 0.378 | 0.017 | 219.0 | 746.6 | 0.914 | 16.5 |
| 150.0 | 250.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.397 | 1.397 | 1.397 | 60.6 | 54.1 | 48.2 | 3.544 | 0.337 | 0.017 | 196.3 | 746.6 | 1.029 | 15.5 |
| 160.0 | 250.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.422 | 1.422 | 1.422 | 61.1 | 54.2 | 47.7 | 3.120 | 0.304 | 0.017 | 179.2 | 746.6 | 1.143 | 14.7 |
| 170.0 | 250.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.422 | 1.422 | 1.422 | 61.7 | 54.2 | 47.3 | 2.791 | 0.278 | 0.017 | 165.0 | 746.6 | 1.260 | 14.0 |
| 180.0 | 250.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.448 | 1.448 | 1.448 | 62.2 | 54.3 | 46.9 | 2.528 | 0.256 | 0.017 | 153.4 | 746.6 | 1.379 | 13.4 |
| 190.0 | 250.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.448 | 1.448 | 1.448 | 62.7 | 54.4 | 46.5 | 2.314 | 0.236 | 0.017 | 144.3 | 746.6 | 1.496 | 12.9 |
| 200.0 | 250.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.448 | 1.448 | 1.448 | 63.3 | 54.5 | 46.2 | 2.136 | 0.220 | 0.017 | 136.0 | 746.6 | 1.615 | 12.4 |
| 210.0 | 250.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.473 | 1.473 | 1.473 | 63.8 | 54.5 | 45.8 | 1.985 | 0.206 | 0.018 | 129.2 | 746.6 | 1.737 | 12.0 |
| 220.0 | 250.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.473 | 1.473 | 1.473 | 64.3 | 54.6 | 45.4 | 1.856 | 0.193 | 0.018 | 123.3 | 746.6 | 1.857 | 11.6 |
| 230.0 | 250.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.499 | 1.499 | 1.499 | 64.8 | 54.7 | 45.1 | 1.745 | 0.183 | 0.018 | 117.9 | 746.6 | 1.981 | 11.2 |
| 240.0 | 250.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.499 | 1.499 | 1.499 | 65.3 | 54.8 | 44.7 | 1.647 | 0.173 | 0.018 | 113.4 | 746.6 | 2.106 | 10.9 |
| 250.0 | 250.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.524 | 1.524 | 1.524 | 65.8 | 54.9 | 44.4 | 1.561 | 0.164 | 0.018 | 109.4 | 746.6 | 2.230 | 10.6 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 275.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.270 | 1.270 | 1.270 | 50.4 | 46.9 | 44.0 | 12.931 | 0.785 | 0.017 | 497.7 | 746.6 | 0.399 | 25.0 |
| 110.0 | 275.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.295 | 1.295 | 1.295 | 50.9 | 47.0 | 43.6 | 8.596 | 0.630 | 0.017 | 376.2 | 746.6 | 0.495 | 22.4 |
| 120.0 | 275.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.295 | 1.295 | 1.295 | 51.3 | 47.0 | 43.2 | 6.454 | 0.528 | 0.017 | 307.2 | 746.6 | 0.594 | 20.5 |
| 130.0 | 275.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.321 | 1.321 | 1.321 | 51.8 | 47.1 | 42.8 | 5.179 | 0.454 | 0.017 | 262.7 | 746.6 | 0.693 | 19.0 |
| 140.0 | 275.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.321 | 1.321 | 1.321 | 52.3 | 47.1 | 42.4 | 4.336 | 0.399 | 0.017 | 230.8 | 746.6 | 0.790 | 17.7 |
| 150.0 | 275.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.346 | 1.346 | 1.346 | 52.8 | 47.2 | 42.0 | 3.736 | 0.356 | 0.018 | 207.1 | 746.6 | 0.889 | 16.7 |
| 160.0 | 275.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.346 | 1.346 | 1.346 | 53.2 | 47.2 | 41.7 | 3.289 | 0.321 | 0.018 | 188.7 | 746.6 | 0.988 | 15.9 |
| 170.0 | 275.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.372 | 1.372 | 1.372 | 53.7 | 47.3 | 41.3 | 2.942 | 0.293 | 0.018 | 173.8 | 746.6 | 1.087 | 15.1 |
| 180.0 | 275.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.372 | 1.372 | 1.372 | 54.2 | 47.3 | 41.0 | 2.665 | 0.269 | 0.018 | 162.1 | 746.6 | 1.189 | 14.5 |
| 190.0 | 275.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.397 | 1.397 | 1.397 | 54.6 | 47.4 | 40.6 | 2.439 | 0.249 | 0.018 | 151.9 | 746.6 | 1.288 | 13.9 |
| 200.0 | 275.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.397 | 1.397 | 1.397 | 55.1 | 47.5 | 40.3 | 2.251 | 0.232 | 0.018 | 143.4 | 746.6 | 1.389 | 13.4 |
| 210.0 | 275.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.397 | 1.397 | 1.397 | 55.5 | 47.5 | 40.0 | 2.092 | 0.217 | 0.019 | 136.2 | 746.6 | 1.491 | 12.9 |
| 220.0 | 275.0 | 568.0 | 473.0 | [illegible] | [illegible] | [illegible] | 80.0 | 10.0 | 1.422 | 1.422 | 1.422 | 56.0 | 47.6 | 39.7 | 1.956 | 0.204 | 0.019 | 129.8 | 746.6 | 1.595 | 12.5 |
| 230.0 | 275.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.422 | 1.422 | 1.422 | 56.4 | 47.7 | 39.4 | 1.838 | 0.192 | 0.019 | 124.4 | 746.6 | 1.699 | 12.1 |
| 240.0 | 275.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.448 | 1.448 | 1.448 | 56.8 | 47.7 | 39.1 | 1.735 | 0.182 | 0.019 | 119.4 | 746.6 | 1.803 | 11.7 |
| 250.0 | 275.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.448 | 1.448 | 1.448 | 57.3 | 47.8 | 38.8 | 1.644 | 0.173 | 0.019 | 114.9 | 746.6 | 1.908 | 11.4 |

Date: 8/13/92 Time: 8:22 Filename: Support analysis cases (si)

| Ht (mm) | OD (mm) | L1 (mm) | L2 (mm) | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | T1 (mm) | T2 (mm) | T3 (mm) | Sig1 (MPa) | Sig2 (MPa) | Sig3 (MPa) | Q70 (W) | Q4.3 (W) | Q1.8 (W) | Q r.t. (W) | Fg (kg) | dx (mm) | Nat f (Hz) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 300.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.219 | 1.219 | 1.219 | 44.4 | 41.5 | 38.9 | 13.584 | 0.824 | 0.018 | 523.1 | 746.6 | 0.353 | 26.6 |
| 110.0 | 300.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.245 | 1.245 | 1.245 | 44.9 | 41.5 | 38.5 | 9.029 | 0.662 | 0.018 | 395.0 | 746.6 | 0.439 | 23.8 |
| 120.0 | 300.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.245 | 1.245 | 1.245 | 45.3 | 41.5 | 38.2 | 6.778 | 0.554 | 0.018 | 322.9 | 746.6 | 0.526 | 21.7 |
| 130.0 | 300.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.270 | 1.270 | 1.270 | 45.7 | 41.6 | 37.8 | 5.439 | 0.477 | 0.018 | 275.8 | 746.6 | 0.612 | 20.2 |
| 140.0 | 300.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.270 | 1.270 | 1.270 | 46.1 | 41.6 | 37.5 | 4.553 | 0.419 | 0.018 | 242.3 | 746.6 | 0.699 | 18.9 |
| 150.0 | 300.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.295 | 1.295 | 1.295 | 46.5 | 41.6 | 37.2 | 3.923 | 0.373 | 0.019 | 217.6 | 746.6 | 0.785 | 17.8 |
| 160.0 | 300.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.295 | 1.295 | 1.295 | 46.9 | 41.7 | 36.9 | 3.453 | 0.337 | 0.019 | 198.1 | 746.6 | 0.871 | 16.9 |
| 170.0 | 300.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.321 | 1.321 | 1.321 | 47.3 | 41.7 | 36.5 | 3.088 | 0.307 | 0.019 | 182.7 | 746.6 | 0.958 | 16.1 |
| 180.0 | 300.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.321 | 1.321 | 1.321 | 47.7 | 41.8 | 36.2 | 2.797 | 0.283 | 0.019 | 169.9 | 746.6 | 1.046 | 15.4 |
| 190.0 | 300.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.321 | 1.321 | 1.321 | 48.1 | 41.8 | 35.9 | 2.560 | 0.262 | 0.019 | 159.1 | 746.6 | 1.133 | 14.8 |
| 200.0 | 300.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.346 | 1.346 | 1.346 | 48.5 | 41.9 | 35.7 | 2.362 | 0.243 | 0.019 | 150.5 | 746.6 | 1.222 | 14.3 |
| 210.0 | 300.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.346 | 1.346 | 1.346 | 48.9 | 42.0 | 35.4 | 2.195 | 0.228 | 0.019 | 142.7 | 746.6 | 1.308 | 13.8 |
| 220.0 | 300.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.372 | 1.372 | 1.372 | 49.3 | 42.0 | 35.1 | 2.052 | 0.214 | 0.020 | 136.4 | 746.6 | 1.397 | 13.3 |
| 230.0 | 300.0 | 578.0 | 478.0 | [illegible] | [illegible] | [illegible] | [illegible] | 10.0 | 1.372 | 1.372 | 1.372 | 49.7 | 42.1 | 34.8 | 1.929 | 0.202 | 0.020 | 130.4 | 746.6 | 1.488 | 12.9 |
| 240.0 | 300.0 | 588.0 | 483.0 | [illegible] | [illegible] | [illegible] | [illegible] | 10.0 | 1.397 | 1.397 | 1.397 | 50.1 | 42.1 | 34.6 | 1.820 | 0.191 | 0.020 | 125.1 | 746.6 | 1.577 | 12.6 |
| 250.0 | 300.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.397 | 1.397 | 1.397 | 50.4 | 42.2 | 34.3 | 1.725 | 0.181 | 0.020 | 120.9 | 746.6 | 1.669 | 12.2 |

Date: 8/13/92 Time: 8:09 Filename: Support analysis cases (si)

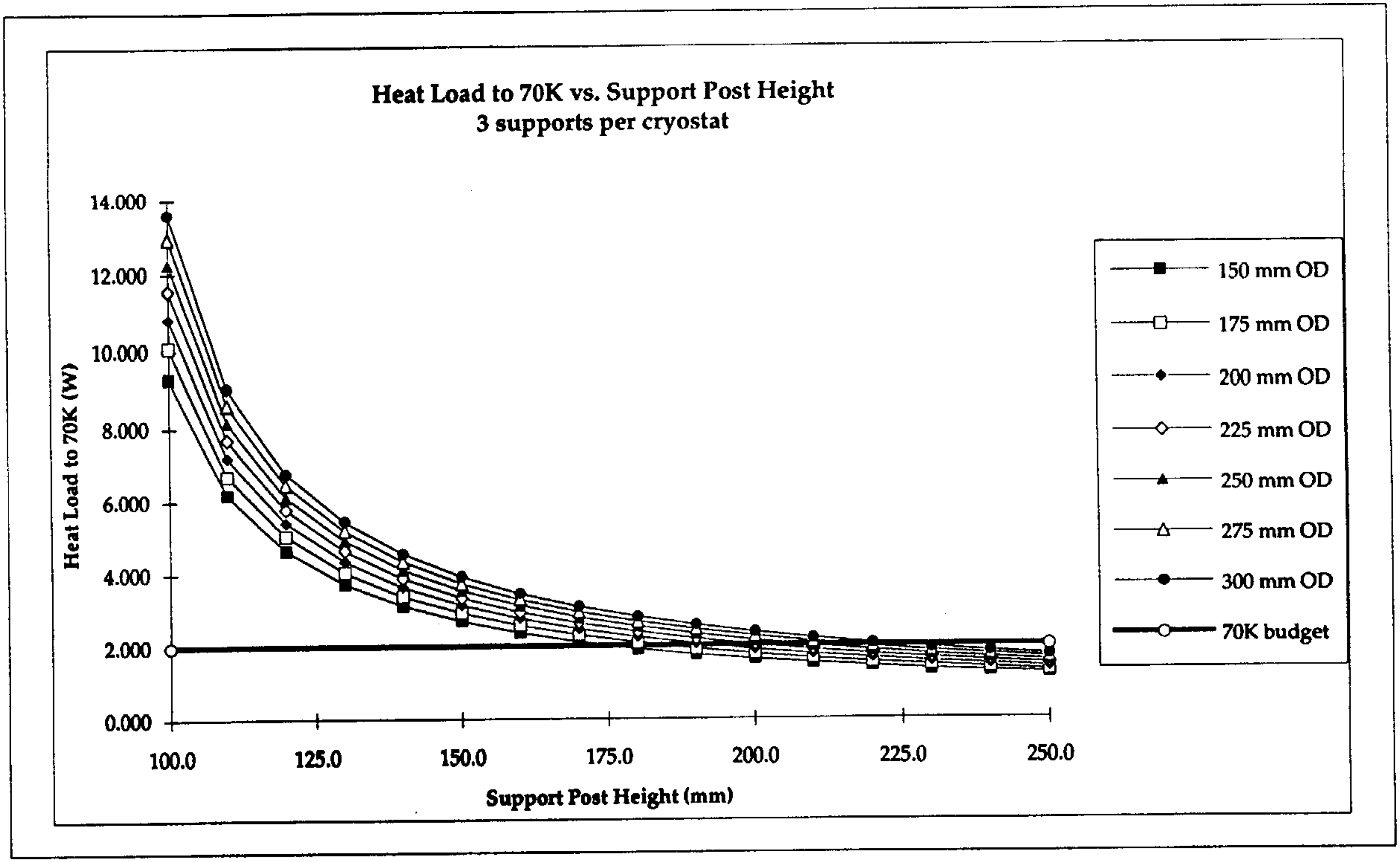


Figure A-1

Date: 8/13/92 Time: 8:09 Filename: Support analysis cases (si)

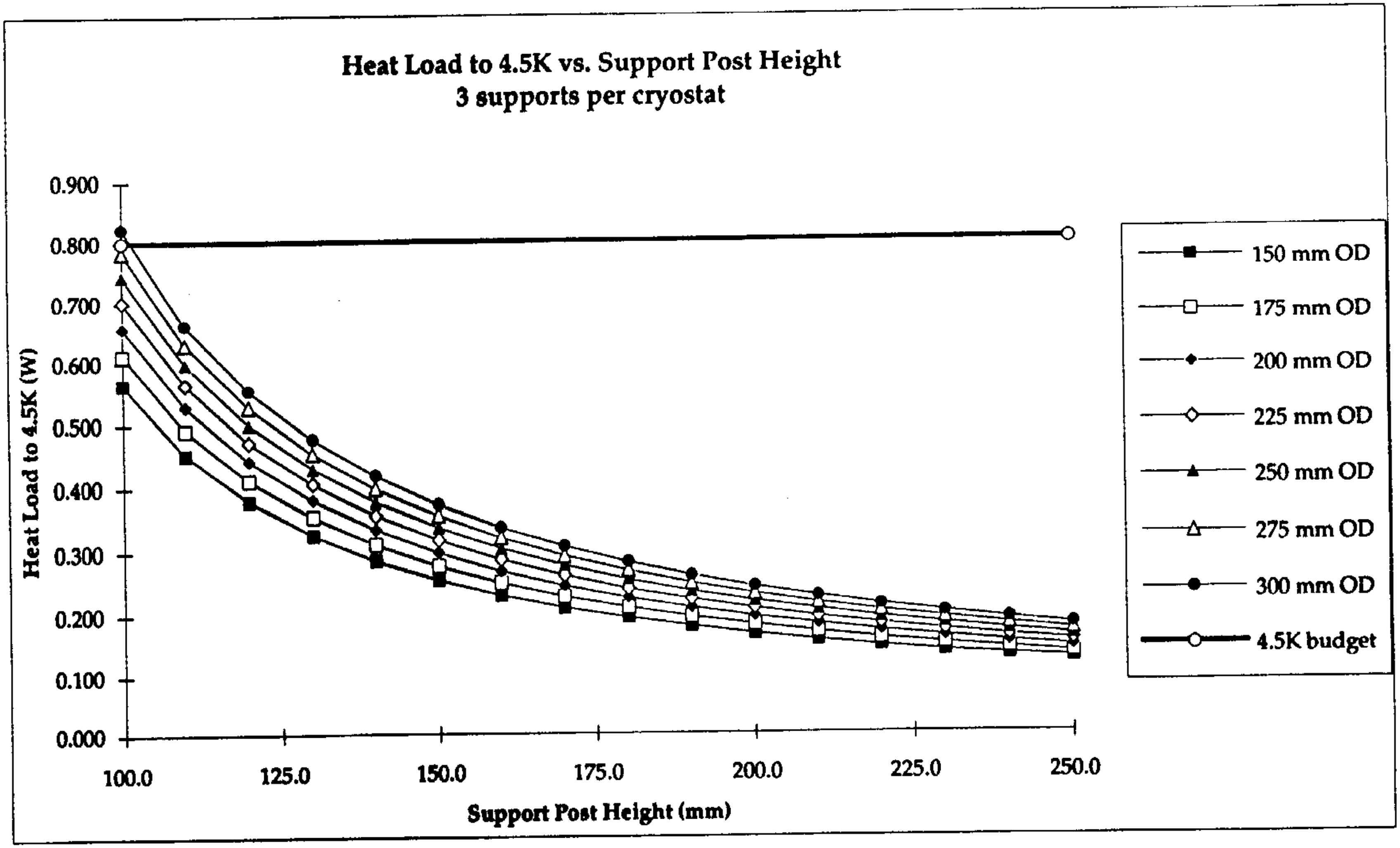


Figure A-2

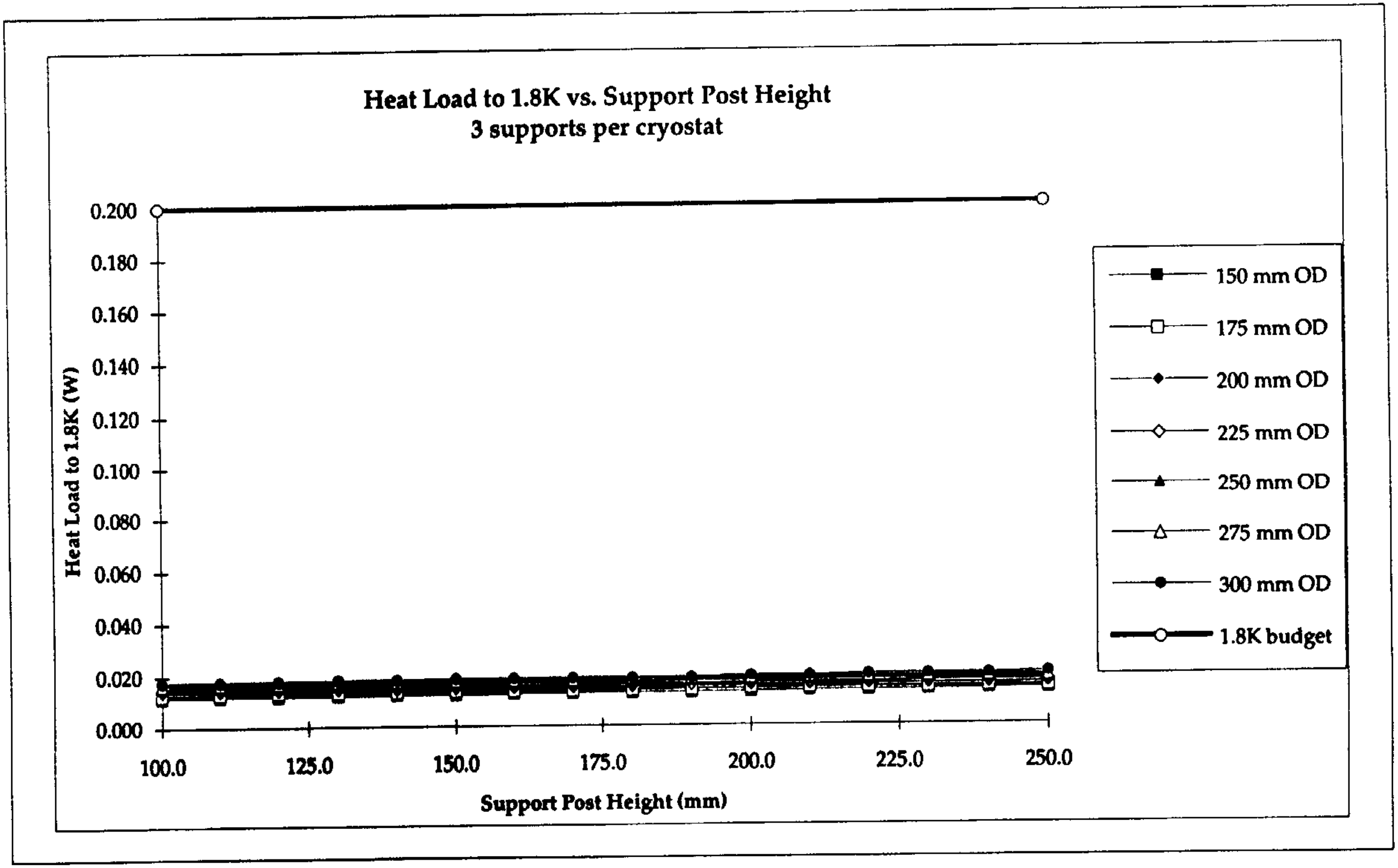
Heat Load to 1.8K vs. Support Post Height
3 supports per cryostat
Heat Load to 1.8K (W)
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
100.0
125.0
150.0
175.0
200.0
225.0
250.0
Support Post Height (mm)
150 mm OD
175 mm OD
200 mm OD
225 mm OD
250 mm OD
275 mm OD
300 mm OD
1.8K budget

Figure A-3

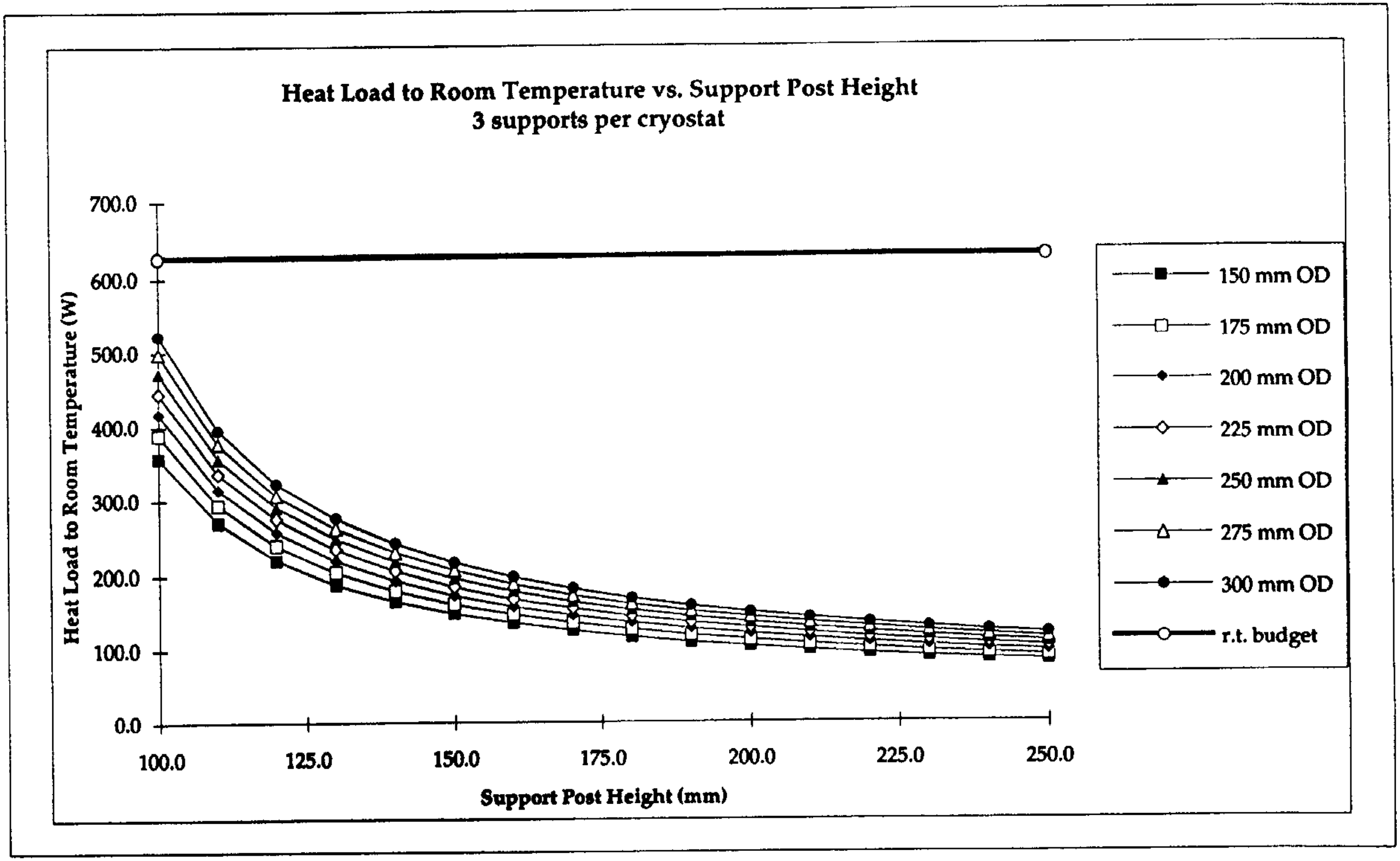
Heat Load to Room Temperature vs. Support Post Height
3 supports per cryostat
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Heat Load to Room Temperature (W)
100.0
125.0
150.0
175.0
200.0
225.0
250.0
Support Post Height (mm)
150 mm OD
175 mm OD
200 mm OD
225 mm OD
250 mm OD
275 mm OD
300 mm OD
r.t. budget

Figure A-4

Date: 8/13/92 Time: 8:09 Filename: Support analysis cases (si)

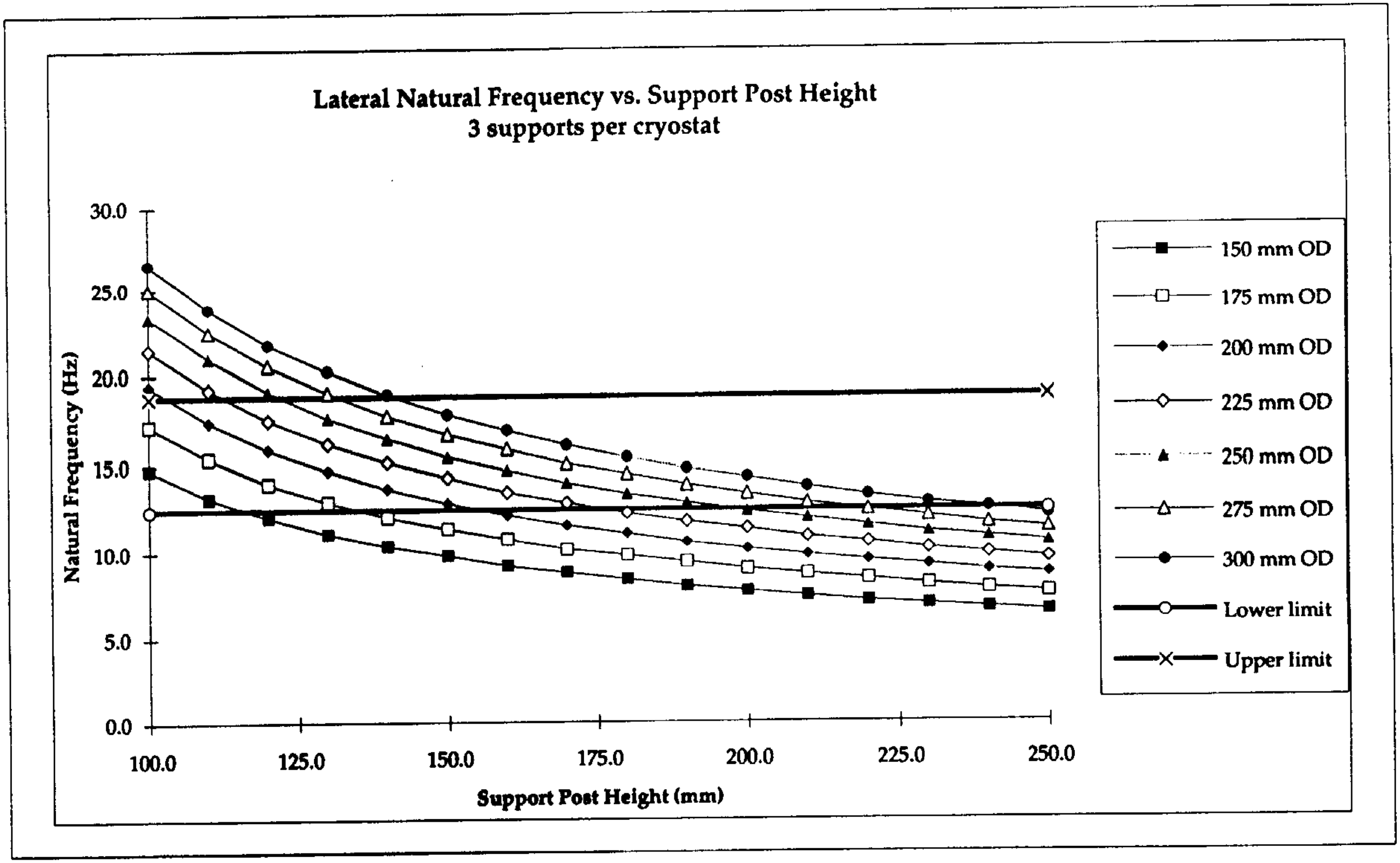


Figure A-5

# APPENDIX B

## Thermal and Structural Analysis Results
## 4 Supports per Cryostat

Date: 8/13/92 Time: 8:25 Filename: Support analysis cases (si)

TESLA Test Cell Support Analysis
4 supports per cryostat
T.Nicol - Fermilab - August 1992

| Refrigeration System W@R.T. to W@T | | |
|---|---|---|
| T (K) | eff | W/W |
| 70 | 20% | 16 |
| 4.5 | 20% | 328 |
| 1.8 | 10% | 1657 |

| Heat Load Budget (W) | | |
|---|---|---|
| T (K) | Q (W) | Q r.t. (W) |
| 70 | 1.50 | 25 |
| 4.5 | 0.60 | 197 |
| 1.8 | 0.15 | 249 |

| Data for plotting budget values | | | | | | |
|---|---|---|---|---|---|---|
| Ht (mm) | Q70 (W) | Q4.5 (W) | Q1.8 (W) | Q r.t. (W) | Nat f (Hz) | Nat f (Hz) |
| 100 | 1.50 | 0.60 | 0.15 | 470 | 12.50 | 18.75 |
| 250 | 1.50 | 0.60 | 0.15 | 470 | 12.50 | 18.75 |

| Ht (mm) | OD (mm) | L1 (mm) | L2 (mm) | L3 (mm) | L4 (mm) | LTh1 (mm) | LTh2 (mm) | LTh3 (mm) | T1 (mm) | T2 (mm) | T3 (mm) | Sig1 (MPa) | Sig2 (MPa) | Sig3 (MPa) | Q70 (W) | Q4.5 (W) | Q1.8 (W) | Q r.t. (W) | Fg (kg) | dx (mm) | Nat f (Hz) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 150.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.473 | 1.473 | 1.473 | 105.7 | 98.1 | 91.6 | 8.036 | 0.488 | 0.010 | 309.3 | 559.9 | 0.978 | 15.9 |
| 110.0 | 150.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.473 | 1.473 | 1.473 | 106.8 | 98.2 | 90.6 | 5.345 | 0.392 | 0.010 | 233.8 | 559.9 | 1.224 | 14.3 |
| 120.0 | 150.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.499 | 1.499 | 1.499 | 107.9 | 98.3 | 89.8 | 4.016 | 0.328 | 0.011 | 191.3 | 559.9 | 1.473 | 13.0 |
| 130.0 | 150.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.499 | 1.499 | 1.499 | 109.0 | 98.4 | 88.9 | 3.225 | 0.283 | 0.011 | 163.4 | 559.9 | 1.727 | 12.0 |
| 140.0 | 150.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.524 | 1.524 | 1.524 | 110.1 | 98.5 | 88.1 | 2.701 | 0.248 | 0.011 | 143.8 | 559.9 | 1.984 | 11.2 |
| 150.0 | 150.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.549 | 1.549 | 1.549 | 111.1 | 98.7 | 87.2 | 2.329 | 0.222 | 0.011 | 129.2 | 559.9 | 2.245 | 10.5 |
| 160.0 | 150.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.549 | 1.549 | 1.549 | 112.2 | 98.8 | 86.4 | 2.051 | 0.200 | 0.011 | 117.7 | 559.9 | 2.512 | 10.0 |
| 170.0 | 150.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.575 | 1.575 | 1.575 | 113.2 | 98.9 | 85.7 | 1.836 | 0.183 | 0.011 | 108.7 | 559.9 | 2.781 | 9.5 |
| 180.0 | 150.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.575 | 1.575 | 1.575 | 114.3 | 99.1 | 84.9 | 1.664 | 0.168 | 0.011 | 101.0 | 559.9 | 3.056 | 9.0 |
| 190.0 | 150.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.600 | 1.600 | 1.600 | 115.3 | 99.2 | 84.2 | 1.523 | 0.156 | 0.011 | 95.0 | 559.9 | 3.335 | 8.6 |
| 200.0 | 150.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.600 | 1.600 | 1.600 | 116.3 | 99.4 | 83.5 | 1.406 | 0.145 | 0.011 | 89.6 | 559.9 | 3.620 | 8.3 |
| 210.0 | 150.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.626 | 1.626 | 1.626 | 117.3 | 99.6 | 82.8 | 1.308 | 0.136 | 0.012 | 85.2 | 559.9 | 3.909 | 8.0 |
| 220.0 | 150.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.626 | 1.626 | 1.626 | 118.3 | 99.7 | 82.1 | 1.223 | 0.128 | 0.012 | 81.2 | 559.9 | 4.204 | 7.7 |
| 230.0 | 150.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.651 | 1.651 | 1.651 | 119.3 | 99.9 | 81.5 | 1.150 | 0.120 | 0.012 | 77.9 | 559.9 | 4.503 | 7.4 |
| 240.0 | 150.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.676 | 1.676 | 1.676 | 120.3 | 100.1 | 80.8 | 1.086 | 0.114 | 0.012 | 74.8 | 559.9 | 4.808 | 7.2 |
| 250.0 | 150.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.676 | 1.676 | 1.676 | 121.3 | 100.2 | 80.2 | 1.030 | 0.108 | 0.012 | 72.0 | 559.9 | 5.118 | 7.0 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 175.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.372 | 1.372 | 1.372 | 84.2 | 78.2 | 73.1 | 8.727 | 0.529 | 0.011 | 336.1 | 559.9 | 0.724 | 18.5 |
| 110.0 | 175.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.372 | 1.372 | 1.372 | 85.1 | 78.3 | 72.3 | 5.804 | 0.426 | 0.011 | 254.0 | 559.9 | 0.907 | 16.6 |
| 120.0 | 175.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.397 | 1.397 | 1.397 | 85.9 | 78.4 | 71.6 | 4.360 | 0.356 | 0.012 | 207.8 | 559.9 | 1.090 | 15.1 |
| 130.0 | 175.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.397 | 1.397 | 1.397 | 86.8 | 78.4 | 70.9 | 3.501 | 0.307 | 0.012 | 177.5 | 559.9 | 1.275 | 14.0 |
| 140.0 | 175.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.422 | 1.422 | 1.422 | 87.6 | 78.5 | 70.3 | 2.932 | 0.270 | 0.012 | 156.2 | 559.9 | 1.466 | 13.0 |
| 150.0 | 175.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.422 | 1.422 | 1.422 | 88.4 | 78.6 | 69.6 | 2.528 | 0.241 | 0.012 | 140.1 | 559.9 | 1.656 | 12.3 |
| 160.0 | 175.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.448 | 1.448 | 1.448 | 89.3 | 78.7 | 69.0 | 2.226 | 0.217 | 0.012 | 127.8 | 559.9 | 1.849 | 11.6 |
| 170.0 | 175.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.448 | 1.448 | 1.448 | 90.1 | 78.8 | 68.4 | 1.992 | 0.198 | 0.012 | 118.0 | 559.9 | 2.045 | 11.0 |
| 180.0 | 175.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.473 | 1.473 | 1.473 | 90.9 | 78.9 | 67.8 | 1.805 | 0.182 | 0.012 | 109.7 | 559.9 | 2.243 | 10.5 |
| 190.0 | 175.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.473 | 1.473 | 1.473 | 91.7 | 79.1 | 67.2 | 1.653 | 0.169 | 0.012 | 102.8 | 559.9 | 2.446 | 10.1 |
| 200.0 | 175.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.499 | 1.499 | 1.499 | 92.5 | 79.2 | 66.7 | 1.526 | 0.157 | 0.012 | 97.2 | 559.9 | 2.652 | 9.7 |
| 210.0 | 175.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.499 | 1.499 | 1.499 | 93.3 | 79.3 | 66.1 | 1.418 | 0.147 | 0.013 | 92.4 | 559.9 | 2.858 | 9.3 |
| 220.0 | 175.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.524 | 1.524 | 1.524 | 94.1 | 79.4 | 65.6 | 1.327 | 0.138 | 0.013 | 88.1 | 559.9 | 3.071 | 9.0 |
| 230.0 | 175.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.524 | 1.524 | 1.524 | 94.8 | 79.6 | 65.1 | 1.247 | 0.131 | 0.013 | 84.2 | 559.9 | 3.284 | 8.7 |
| 240.0 | 175.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.549 | 1.549 | 1.549 | 95.6 | 79.7 | 64.5 | 1.178 | 0.124 | 0.013 | 81.1 | 559.9 | 3.503 | 8.4 |
| 250.0 | 175.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.549 | 1.549 | 1.549 | 96.4 | 79.8 | 64.0 | 1.116 | 0.117 | 0.013 | 78.4 | 559.9 | 3.726 | 8.2 |

Date: 8/13/92 Time: 8:25 Filename: Support analysis cases (sl)

| Ht | OD | L1 | L2 | L3 | L4 | LTh1 | LTh2 | LTh3 | T1 | T2 | T3 | Sig1 | Sig2 | Sig3 | Q70 | Q4.5 | Q1.8 | Q r.s. | Fs | dx | Nat f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (MPa) | (MPa) | (MPa) | (W) | (W) | (W) | (W) | (kg) | (mm) | (Hz) |
| 100.0 | 200.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.270 | 1.270 | 1.270 | 69.2 | 64.3 | 60.2 | 9.383 | 0.569 | 0.012 | 361.3 | 559.9 | 0.569 | 20.9 |
| 110.0 | 200.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.295 | 1.295 | 1.295 | 69.9 | 64.4 | 59.6 | 6.240 | 0.458 | 0.012 | 273.0 | 559.9 | 0.711 | 18.7 |
| 120.0 | 200.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.295 | 1.295 | 1.295 | 70.6 | 64.5 | 59.0 | 4.686 | 0.383 | 0.012 | 223.3 | 559.9 | 0.856 | 17.1 |
| 130.0 | 200.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.321 | 1.321 | 1.321 | 71.3 | 64.5 | 58.4 | 3.762 | 0.330 | 0.013 | 190.9 | 559.9 | 1.001 | 15.8 |
| 140.0 | 200.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.321 | 1.321 | 1.321 | 72.0 | 64.6 | 57.9 | 3.151 | 0.290 | 0.013 | 167.7 | 559.9 | 1.146 | 14.7 |
| 150.0 | 200.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.346 | 1.346 | 1.346 | 72.6 | 64.7 | 57.4 | 2.716 | 0.258 | 0.013 | 150.7 | 559.9 | 1.293 | 13.9 |
| 160.0 | 200.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.346 | 1.346 | 1.346 | 73.3 | 64.8 | 56.9 | 2.391 | 0.233 | 0.013 | 137.4 | 559.9 | 1.443 | 13.1 |
| 170.0 | 200.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.372 | 1.372 | 1.372 | 74.0 | 64.8 | 56.4 | 2.140 | 0.213 | 0.013 | 126.6 | 559.9 | 1.593 | 12.5 |
| 180.0 | 200.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.372 | 1.372 | 1.372 | 74.6 | 64.9 | 55.9 | 1.939 | 0.196 | 0.013 | 117.7 | 559.9 | 1.745 | 11.9 |
| 190.0 | 200.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.397 | 1.397 | 1.397 | 75.3 | 65.0 | 55.4 | 1.775 | 0.181 | 0.013 | 110.6 | 559.9 | 1.900 | 11.4 |
| 200.0 | 200.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.397 | 1.397 | 1.397 | 75.9 | 65.1 | 54.9 | 1.638 | 0.169 | 0.013 | 104.4 | 559.9 | 2.057 | 11.0 |
| 210.0 | 200.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.422 | 1.422 | 1.422 | 76.6 | 65.2 | 54.5 | 1.523 | 0.158 | 0.013 | 98.9 | 559.9 | 2.215 | 10.6 |
| 220.0 | 200.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.422 | 1.422 | 1.422 | 77.2 | 65.3 | 54.1 | 1.424 | 0.149 | 0.014 | 94.5 | 559.9 | 2.377 | 10.2 |
| 230.0 | 200.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.448 | 1.448 | 1.448 | 77.8 | 65.4 | 53.6 | 1.339 | 0.140 | 0.014 | 90.7 | 559.9 | 2.540 | 9.9 |
| 240.0 | 200.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.448 | 1.448 | 1.448 | 78.4 | 65.5 | 53.2 | 1.264 | 0.133 | 0.014 | 87.0 | 559.9 | 2.705 | 9.6 |
| 250.0 | 200.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.448 | 1.448 | 1.448 | 79.1 | 65.6 | 52.8 | 1.198 | 0.126 | 0.014 | 83.8 | 559.9 | 2.873 | 9.3 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 225.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.219 | 1.219 | 1.219 | 58.3 | 54.2 | 50.8 | 10.010 | 0.607 | 0.013 | 385.4 | 559.9 | 0.467 | 23.1 |
| 110.0 | 225.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.219 | 1.219 | 1.219 | 58.9 | 54.3 | 50.3 | 6.656 | 0.488 | 0.013 | 291.2 | 559.9 | 0.584 | 20.6 |
| 120.0 | 225.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.245 | 1.245 | 1.245 | 59.4 | 54.3 | 49.8 | 4.998 | 0.409 | 0.013 | 238.1 | 559.9 | 0.701 | 18.8 |
| 130.0 | 225.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.245 | 1.245 | 1.245 | 60.0 | 54.4 | 49.3 | 4.012 | 0.352 | 0.013 | 203.4 | 559.9 | 0.818 | 17.4 |
| 140.0 | 225.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.270 | 1.270 | 1.270 | 60.6 | 54.4 | 48.9 | 3.359 | 0.309 | 0.013 | 178.6 | 559.9 | 0.935 | 16.3 |
| 150.0 | 225.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.270 | 1.270 | 1.270 | 61.1 | 54.5 | 48.4 | 2.896 | 0.276 | 0.014 | 160.4 | 559.9 | 1.054 | 15.4 |
| 160.0 | 225.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.270 | 1.270 | 1.270 | 61.7 | 54.6 | 48.0 | 2.549 | 0.249 | 0.014 | 146.3 | 559.9 | 1.176 | 14.5 |
| 170.0 | 225.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.295 | 1.295 | 1.295 | 62.2 | 54.6 | 47.6 | 2.281 | 0.227 | 0.014 | 134.7 | 559.9 | 1.295 | 13.8 |
| 180.0 | 225.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.295 | 1.295 | 1.295 | 62.8 | 54.7 | 47.2 | 2.066 | 0.209 | 0.014 | 125.5 | 559.9 | 1.420 | 13.2 |
| 190.0 | 225.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.321 | 1.321 | 1.321 | 63.3 | 54.8 | 46.8 | 1.892 | 0.193 | 0.014 | 117.8 | 559.9 | 1.542 | 12.7 |
| 200.0 | 225.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.321 | 1.321 | 1.321 | 63.9 | 54.9 | 46.4 | 1.746 | 0.180 | 0.014 | 111.1 | 559.9 | 1.669 | 12.2 |
| 210.0 | 225.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.346 | 1.346 | 1.346 | 64.4 | 54.9 | 46.0 | 1.623 | 0.169 | 0.014 | 105.3 | 559.9 | 1.793 | 11.8 |
| 220.0 | 225.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.346 | 1.346 | 1.346 | 64.9 | 55.0 | 45.7 | 1.518 | 0.158 | 0.015 | 100.9 | 559.9 | 1.923 | 11.4 |
| 230.0 | 225.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.372 | 1.372 | 1.372 | 65.4 | 55.1 | 45.3 | 1.426 | 0.149 | 0.015 | 96.4 | 559.9 | 2.052 | 11.0 |
| 240.0 | 225.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.372 | 1.372 | 1.372 | 66.0 | 55.2 | 44.9 | 1.347 | 0.141 | 0.015 | 92.5 | 559.9 | 2.182 | 10.7 |
| 250.0 | 225.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.372 | 1.372 | 1.372 | 66.5 | 55.3 | 44.6 | 1.276 | 0.134 | 0.015 | 89.4 | 559.9 | 2.314 | 10.4 |

Date: 8/13/92 Time: 8:25 Filename: Support analysis cases (si)

| Ht | OD | L1 | L2 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | T1 | T2 | T3 | Sig1 | Sig2 | Sig3 | Q70 | Q4.5 | Q1.8 | Q r.t. | Fx | dx | Nat f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mm) | (mm) | (mm) | (mm) | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | (mm) | (mm) | (mm) | (MPa) | (MPa) | (MPa) | (W) | (W) | (W) | (W) | (kg) | (mm) | (Hz) |
| 100.0 | 250.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.143 | 1.143 | 1.143 | 50.0 | 46.6 | 43.6 | 10.613 | 0.644 | 0.014 | 408.5 | 559.9 | 0.396 | 25.1 |
| 110.0 | 250.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.168 | 1.168 | 1.168 | 50.5 | 46.6 | 43.2 | 7.056 | 0.518 | 0.014 | 308.5 | 559.9 | 0.493 | 22.4 |
| 120.0 | 250.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.168 | 1.168 | 1.168 | 51.0 | 46.7 | 42.8 | 5.298 | 0.433 | 0.014 | 252.2 | 559.9 | 0.592 | 20.5 |
| 130.0 | 250.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.194 | 1.194 | 1.194 | 51.5 | 46.7 | 42.4 | 4.252 | 0.373 | 0.014 | 215.6 | 559.9 | 0.691 | 19.0 |
| 140.0 | 250.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.194 | 1.194 | 1.194 | 52.0 | 46.8 | 42.0 | 3.560 | 0.327 | 0.014 | 189.3 | 559.9 | 0.790 | 17.7 |
| 150.0 | 250.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.219 | 1.219 | 1.219 | 52.4 | 46.8 | 41.7 | 3.068 | 0.292 | 0.014 | 170.0 | 559.9 | 0.889 | 16.7 |
| 160.0 | 250.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.219 | 1.219 | 1.219 | 52.9 | 46.9 | 41.3 | 2.701 | 0.264 | 0.015 | 154.9 | 559.9 | 0.991 | 15.8 |
| 170.0 | 250.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.219 | 1.219 | 1.219 | 53.4 | 46.9 | 40.9 | 2.416 | 0.241 | 0.015 | 142.7 | 559.9 | 1.090 | 15.1 |
| 180.0 | 250.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.245 | 1.245 | 1.245 | 53.8 | 47.0 | 40.6 | 2.189 | 0.221 | 0.015 | 132.9 | 559.9 | 1.191 | 14.4 |
| 190.0 | 250.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.245 | 1.245 | 1.245 | 54.3 | 47.0 | 40.3 | 2.004 | 0.205 | 0.015 | 124.8 | 559.9 | 1.295 | 13.9 |
| 200.0 | 250.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.270 | 1.270 | 1.270 | 54.7 | 47.1 | 39.9 | 1.849 | 0.191 | 0.015 | 117.6 | 559.9 | 1.397 | 13.3 |
| 210.0 | 250.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.270 | 1.270 | 1.270 | 55.2 | 47.2 | 39.6 | 1.719 | 0.178 | 0.015 | 111.8 | 559.9 | 1.501 | 12.9 |
| 220.0 | 250.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.295 | 1.295 | 1.295 | 55.6 | 47.2 | 39.3 | 1.607 | 0.168 | 0.015 | 106.7 | 559.9 | 1.608 | 12.4 |
| 230.0 | 250.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.295 | 1.295 | 1.295 | 56.1 | 47.3 | 39.0 | 1.510 | 0.158 | 0.015 | 102.1 | 559.9 | 1.715 | 12.0 |
| 240.0 | 250.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.295 | 1.295 | 1.295 | 56.5 | 47.4 | 38.7 | 1.426 | 0.150 | 0.016 | 98.2 | 559.9 | 1.821 | 11.7 |
| 250.0 | 250.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.321 | 1.321 | 1.321 | 56.9 | 47.5 | 38.4 | 1.351 | 0.142 | 0.016 | 94.8 | 559.9 | 1.930 | 11.4 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.0 | 275.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.118 | 1.118 | 1.118 | 43.6 | 40.6 | 38.1 | 11.196 | 0.679 | 0.015 | 431.0 | 559.9 | 0.343 | 26.9 |
| 110.0 | 275.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.118 | 1.118 | 1.118 | 44.0 | 40.7 | 37.7 | 7.442 | 0.546 | 0.015 | 325.5 | 559.9 | 0.429 | 24.1 |
| 120.0 | 275.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.118 | 1.118 | 1.118 | 44.4 | 40.7 | 37.4 | 5.588 | 0.457 | 0.015 | 266.1 | 559.9 | 0.513 | 22.0 |
| 130.0 | 275.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.143 | 1.143 | 1.143 | 44.8 | 40.7 | 37.0 | 4.484 | 0.393 | 0.015 | 227.4 | 559.9 | 0.599 | 20.4 |
| 140.0 | 275.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.143 | 1.143 | 1.143 | 45.2 | 40.8 | 36.7 | 3.754 | 0.345 | 0.015 | 199.7 | 559.9 | 0.683 | 19.1 |
| 150.0 | 275.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.168 | 1.168 | 1.168 | 45.7 | 40.8 | 36.4 | 3.235 | 0.308 | 0.015 | 179.2 | 559.9 | 0.770 | 18.0 |
| 160.0 | 275.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.168 | 1.168 | 1.168 | 46.1 | 40.9 | 36.1 | 2.847 | 0.278 | 0.015 | 163.4 | 559.9 | 0.856 | 17.0 |
| 170.0 | 275.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.168 | 1.168 | 1.168 | 46.5 | 40.9 | 35.8 | 2.547 | 0.254 | 0.015 | 150.5 | 559.9 | 0.942 | 16.3 |
| 180.0 | 275.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.194 | 1.194 | 1.194 | 46.9 | 41.0 | 35.5 | 2.307 | 0.233 | 0.016 | 140.1 | 559.9 | 1.029 | 15.6 |
| 190.0 | 275.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.194 | 1.194 | 1.194 | 47.2 | 41.0 | 35.2 | 2.112 | 0.216 | 0.016 | 131.5 | 559.9 | 1.115 | 14.9 |
| 200.0 | 275.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.219 | 1.219 | 1.219 | 47.6 | 41.1 | 34.9 | 1.949 | 0.201 | 0.016 | 124.0 | 559.9 | 1.204 | 14.4 |
| 210.0 | 275.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.219 | 1.219 | 1.219 | 48.0 | 41.1 | 34.6 | 1.811 | 0.188 | 0.016 | 117.8 | 559.9 | 1.290 | 13.9 |
| 220.0 | 275.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.219 | 1.219 | 1.219 | 48.4 | 41.2 | 34.3 | 1.693 | 0.177 | 0.016 | 112.4 | 559.9 | 1.379 | 13.4 |
| 230.0 | 275.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.245 | 1.245 | 1.245 | 48.8 | 41.2 | 34.1 | 1.591 | 0.167 | 0.016 | 107.5 | 559.9 | 1.471 | 13.0 |
| 240.0 | 275.0 | [illegible] | 483.0 | [illegible] | [illegible] | [illegible] | [illegible] | 10.0 | 1.245 | 1.245 | 1.245 | 49.2 | 41.3 | 33.8 | 1.502 | 0.158 | 0.016 | 103.4 | 559.9 | 1.560 | 12.6 |
| 250.0 | 275.0 | 598.0 | 488.0 | 383.0 | 358.0 | 85.0 | 95.0 | 10.0 | 1.270 | 1.270 | 1.270 | 49.5 | 41.4 | 33.6 | 1.423 | 0.150 | 0.017 | 99.8 | 559.9 | 1.651 | 12.3 |

Date: 8/13/92 Time: 8:25 Filename: Support analysis cases (si)

| Ht | OD | L1 | L2 | L3 | L4 | LTh1 | LTh2 | LTh3 | T1 | T2 | T3 | Sig1 | Sig2 | Sig3 | Q70 | Q4.5 | Q1.8 | Q r.t. | Fg | dx | Nat f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (MPa) | (MPa) | (MPa) | (W) | (W) | (W) | (W) | (kg) | (mm) | (Hz) |
| 100.0 | 300.0 | 448.0 | 413.0 | 383.0 | 358.0 | 10.0 | 20.0 | 10.0 | 1.067 | 1.067 | 1.067 | 38.5 | 35.9 | 33.7 | 11.762 | 0.714 | 0.015 | 452.8 | 559.9 | 0.305 | 28.5 |
| 110.0 | 300.0 | 458.0 | 418.0 | 383.0 | 358.0 | 15.0 | 25.0 | 10.0 | 1.067 | 1.067 | 1.067 | 38.8 | 35.9 | 33.4 | 7.818 | 0.573 | 0.015 | 342.0 | 559.9 | 0.381 | 25.6 |
| 120.0 | 300.0 | 468.0 | 423.0 | 383.0 | 358.0 | 20.0 | 30.0 | 10.0 | 1.092 | 1.092 | 1.092 | 39.2 | 35.9 | 33.0 | 5.869 | 0.480 | 0.016 | 279.6 | 559.9 | 0.455 | 23.4 |
| 130.0 | 300.0 | 478.0 | 428.0 | 383.0 | 358.0 | 25.0 | 35.0 | 10.0 | 1.092 | 1.092 | 1.092 | 39.5 | 36.0 | 32.7 | 4.710 | 0.413 | 0.016 | 238.9 | 559.9 | 0.531 | 21.7 |
| 140.0 | 300.0 | 488.0 | 433.0 | 383.0 | 358.0 | 30.0 | 40.0 | 10.0 | 1.118 | 1.118 | 1.118 | 39.9 | 36.0 | 32.5 | 3.942 | 0.362 | 0.016 | 209.8 | 559.9 | 0.605 | 20.3 |
| 150.0 | 300.0 | 498.0 | 438.0 | 383.0 | 358.0 | 35.0 | 45.0 | 10.0 | 1.118 | 1.118 | 1.118 | 40.3 | 36.0 | 32.2 | 3.397 | 0.323 | 0.016 | 188.3 | 559.9 | 0.678 | 19.1 |
| 160.0 | 300.0 | 508.0 | 443.0 | 383.0 | 358.0 | 40.0 | 50.0 | 10.0 | 1.118 | 1.118 | 1.118 | 40.6 | 36.1 | 31.9 | 2.989 | 0.292 | 0.016 | 171.6 | 559.9 | 0.754 | 18.2 |
| 170.0 | 300.0 | 518.0 | 448.0 | 383.0 | 358.0 | 45.0 | 55.0 | 10.0 | 1.143 | 1.143 | 1.143 | 41.0 | 36.1 | 31.6 | 2.674 | 0.266 | 0.016 | 158.0 | 559.9 | 0.831 | 17.3 |
| 180.0 | 300.0 | 528.0 | 453.0 | 383.0 | 358.0 | 50.0 | 60.0 | 10.0 | 1.143 | 1.143 | 1.143 | 41.3 | 36.2 | 31.4 | 2.422 | 0.245 | 0.016 | 147.1 | 559.9 | 0.904 | 16.6 |
| 190.0 | 300.0 | 538.0 | 458.0 | 383.0 | 358.0 | 55.0 | 65.0 | 10.0 | 1.143 | 1.143 | 1.143 | 41.6 | 36.2 | 31.1 | 2.216 | 0.226 | 0.017 | 138.0 | 559.9 | 0.980 | 15.9 |
| 200.0 | 300.0 | 548.0 | 463.0 | 383.0 | 358.0 | 60.0 | 70.0 | 10.0 | 1.168 | 1.168 | 1.168 | 42.0 | 36.3 | 30.9 | 2.045 | 0.211 | 0.017 | 130.1 | 559.9 | 1.057 | 15.3 |
| 210.0 | 300.0 | 558.0 | 468.0 | 383.0 | 358.0 | 65.0 | 75.0 | 10.0 | 1.168 | 1.168 | 1.168 | 42.3 | 36.3 | 30.6 | 1.901 | 0.197 | 0.017 | 123.6 | 559.9 | 1.133 | 14.8 |
| 220.0 | 300.0 | 568.0 | 473.0 | 383.0 | 358.0 | 70.0 | 80.0 | 10.0 | 1.194 | 1.194 | 1.194 | 42.7 | 36.4 | 30.4 | 1.777 | 0.185 | 0.017 | 118.0 | 559.9 | 1.209 | 14.3 |
| 230.0 | 300.0 | 578.0 | 478.0 | 383.0 | 358.0 | 75.0 | 85.0 | 10.0 | 1.194 | 1.194 | 1.194 | 43.0 | 36.4 | 30.1 | 1.670 | 0.175 | 0.017 | 112.8 | 559.9 | 1.288 | 13.9 |
| 240.0 | 300.0 | 588.0 | 483.0 | 383.0 | 358.0 | 80.0 | 90.0 | 10.0 | 1.194 | 1.194 | 1.194 | 43.3 | 36.5 | 29.9 | 1.576 | 0.165 | 0.017 | 108.8 | 559.9 | 1.367 | 13.5 |
| 250.0 | 300.0 | 598.0 | 488.0 | 383.0 | [illegible] | [illegible] | 95.0 | 10.0 | 1.219 | 1.219 | 1.219 | 43.7 | 36.5 | 29.7 | 1.493 | 0.157 | 0.017 | 104.7 | 559.9 | 1.443 | 13.1 |

Date: 8/13/92 Time: 8:15 Filename: Support analysis cases (si)

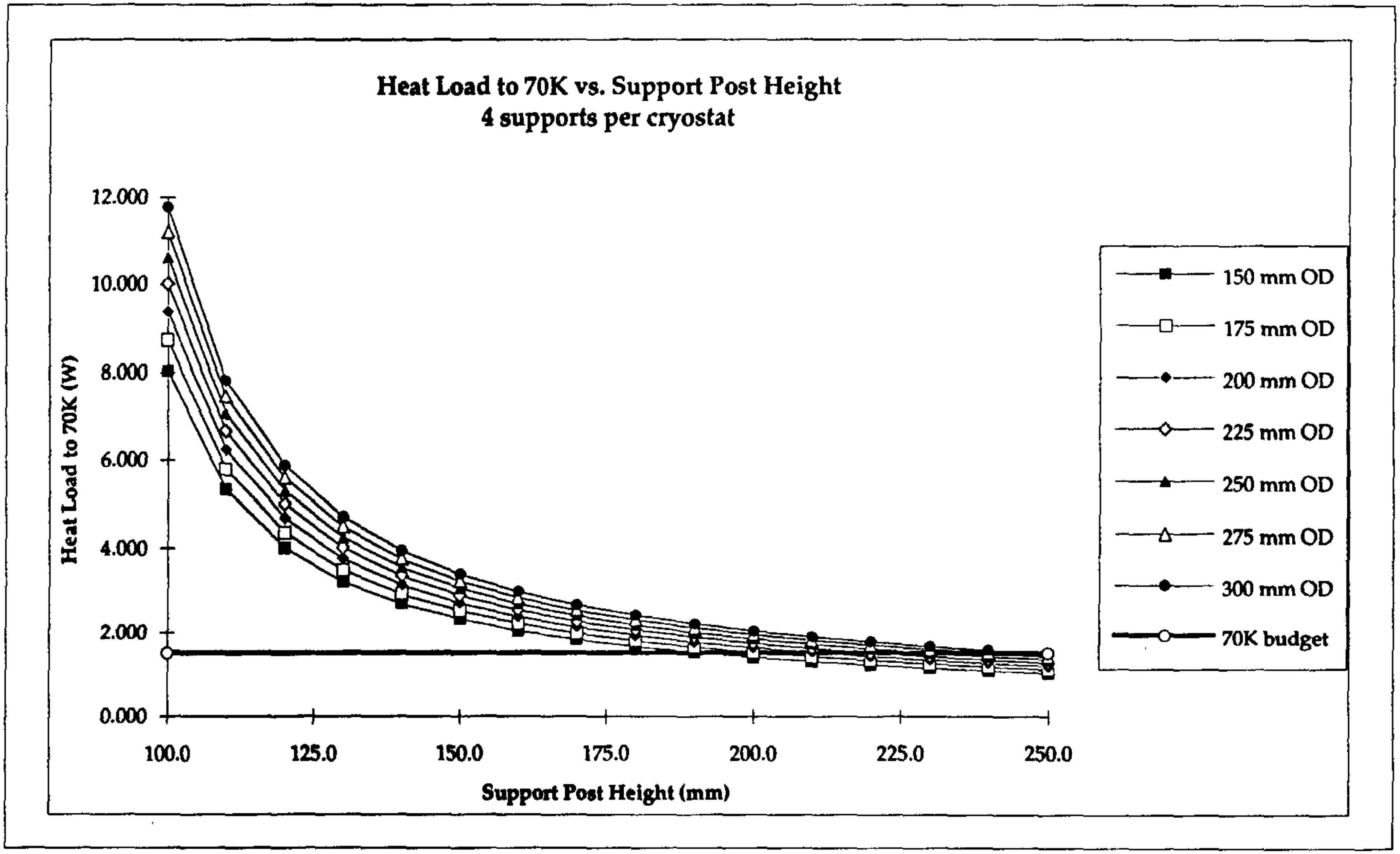


Figure B-1

Date: 8/13/92 Time: 8:15 Filename: Support analysis cases (si)

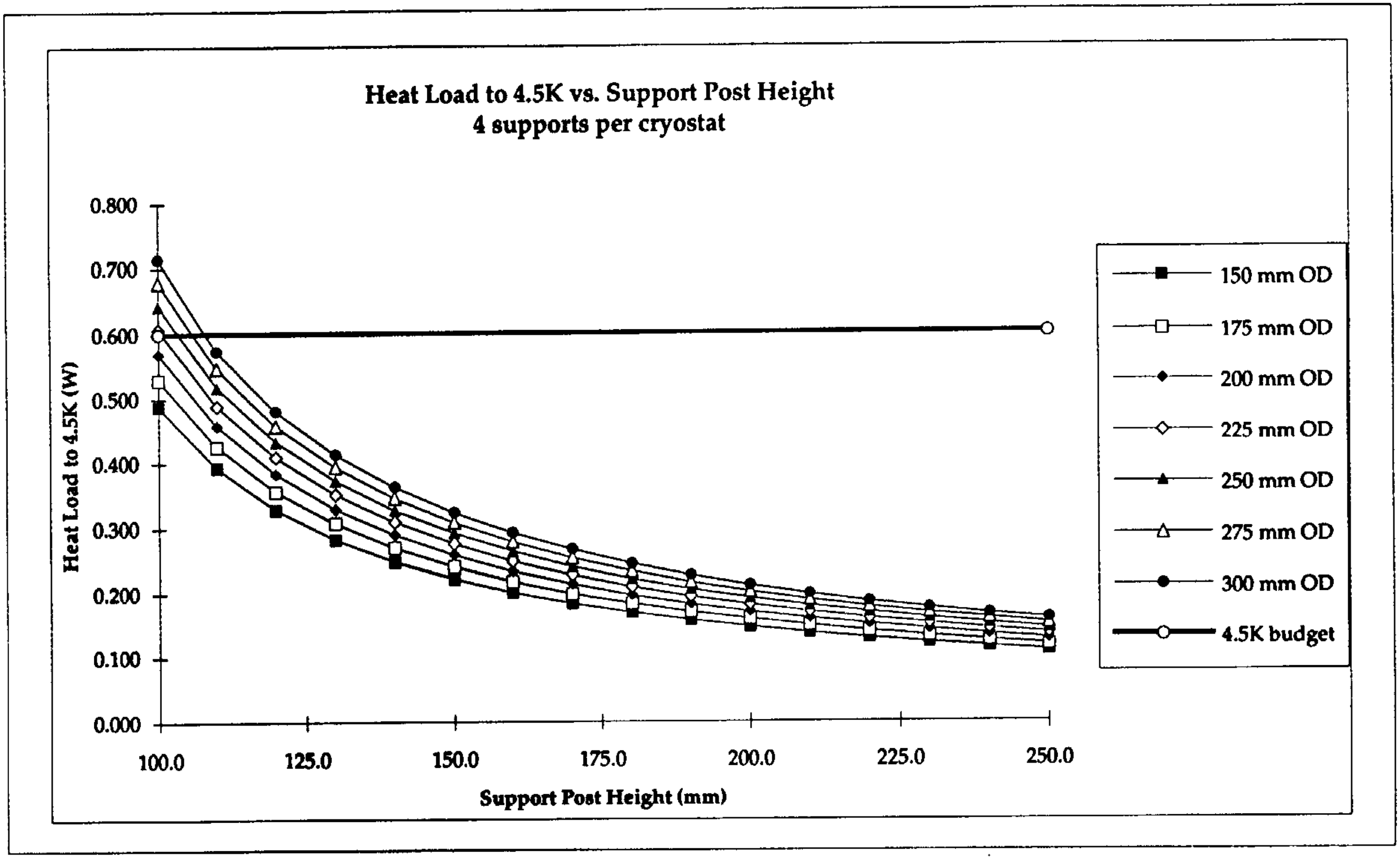


Figure B-2

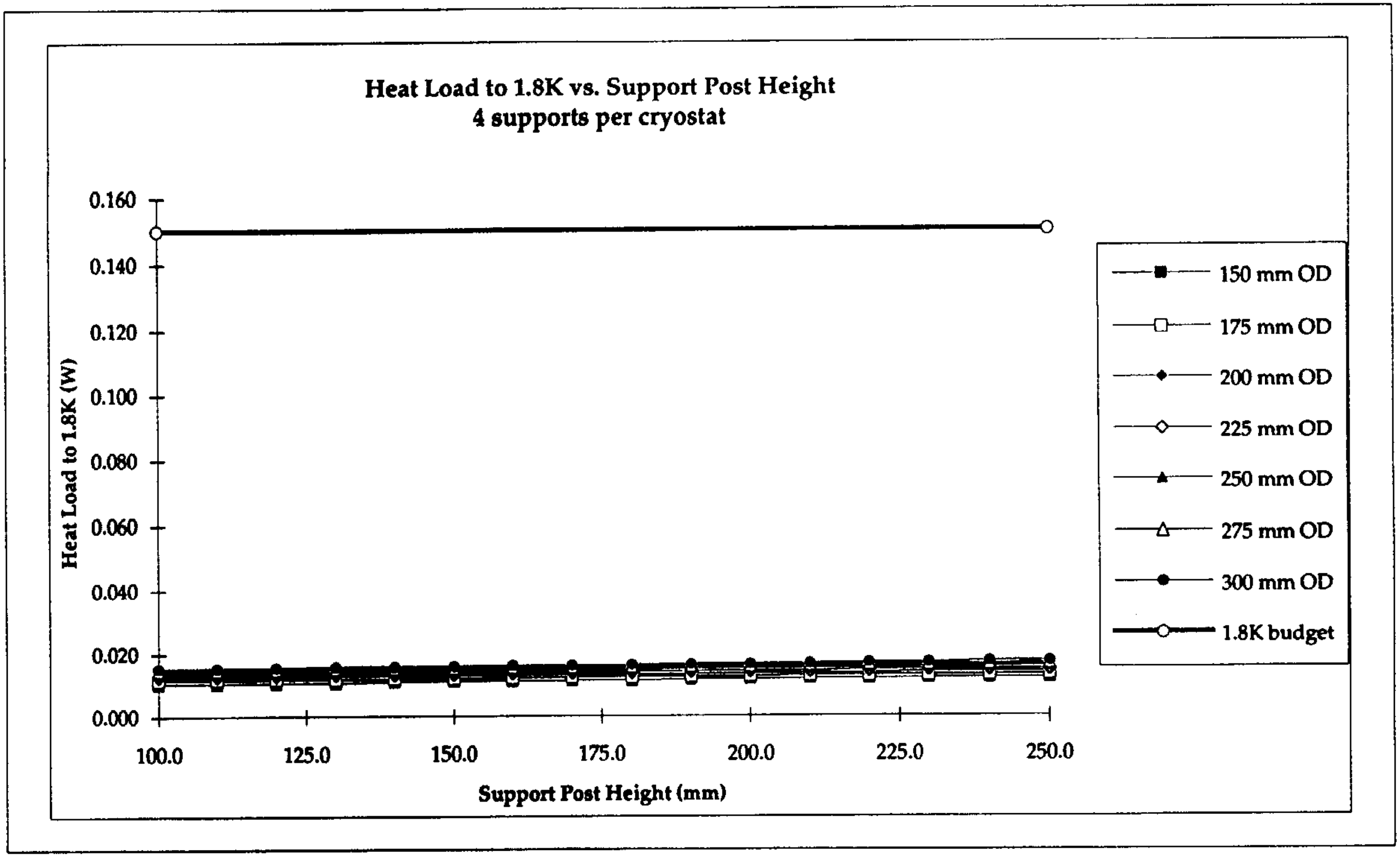
Heat Load to 1.8K vs. Support Post Height
4 supports per cryostat
Heat Load to 1.8K (W)
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
100.0
125.0
150.0
175.0
200.0
225.0
250.0
Support Post Height (mm)
150 mm OD
175 mm OD
200 mm OD
225 mm OD
250 mm OD
275 mm OD
300 mm OD
1.8K budget

Figure B-3

Date: 8/13/92 Time: 8:15 Filename: Support analysis cases (si)

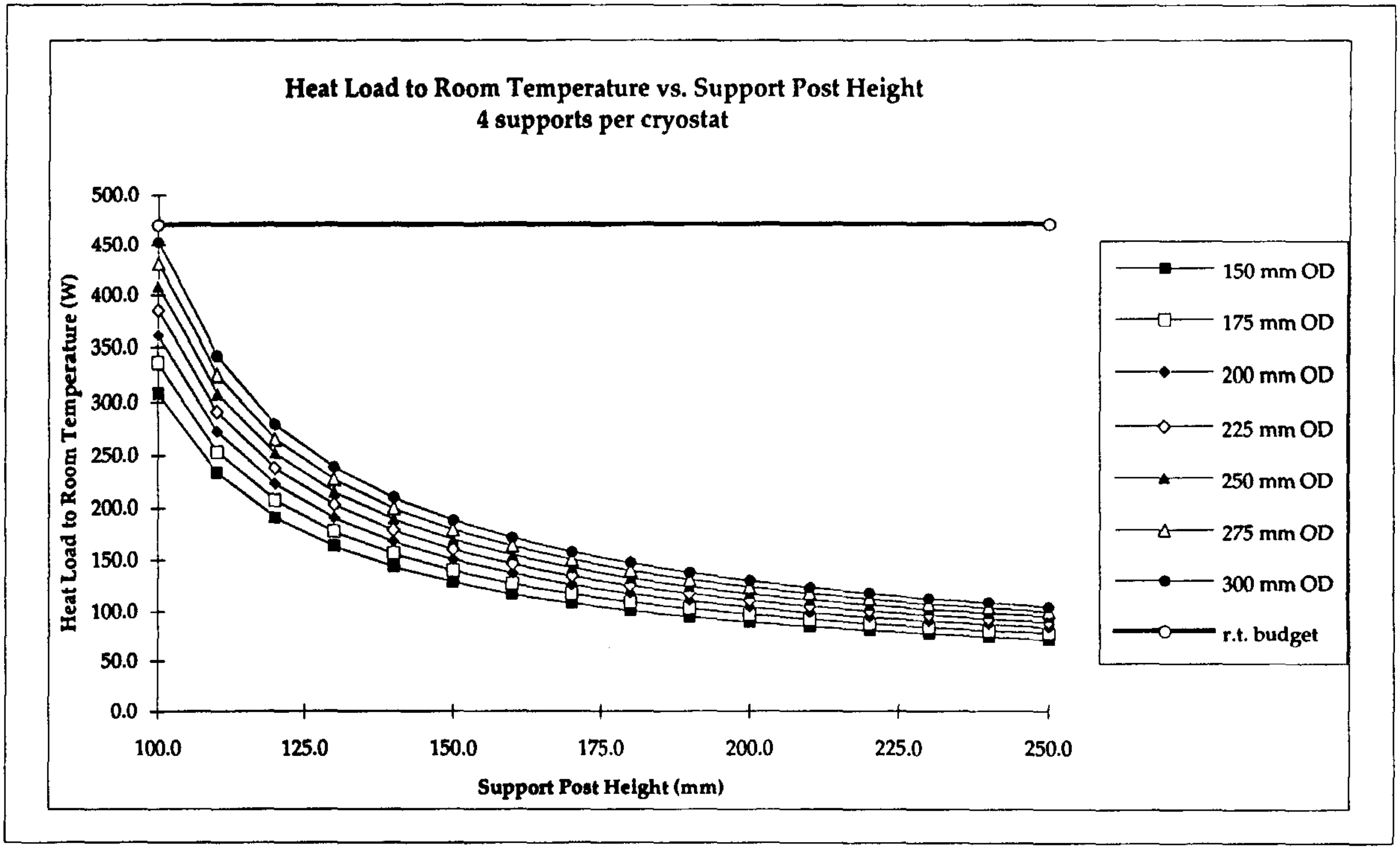


Figure B-4

Date: 8/13/92 Time: 8:15 Filename: Support analysis cases (si)

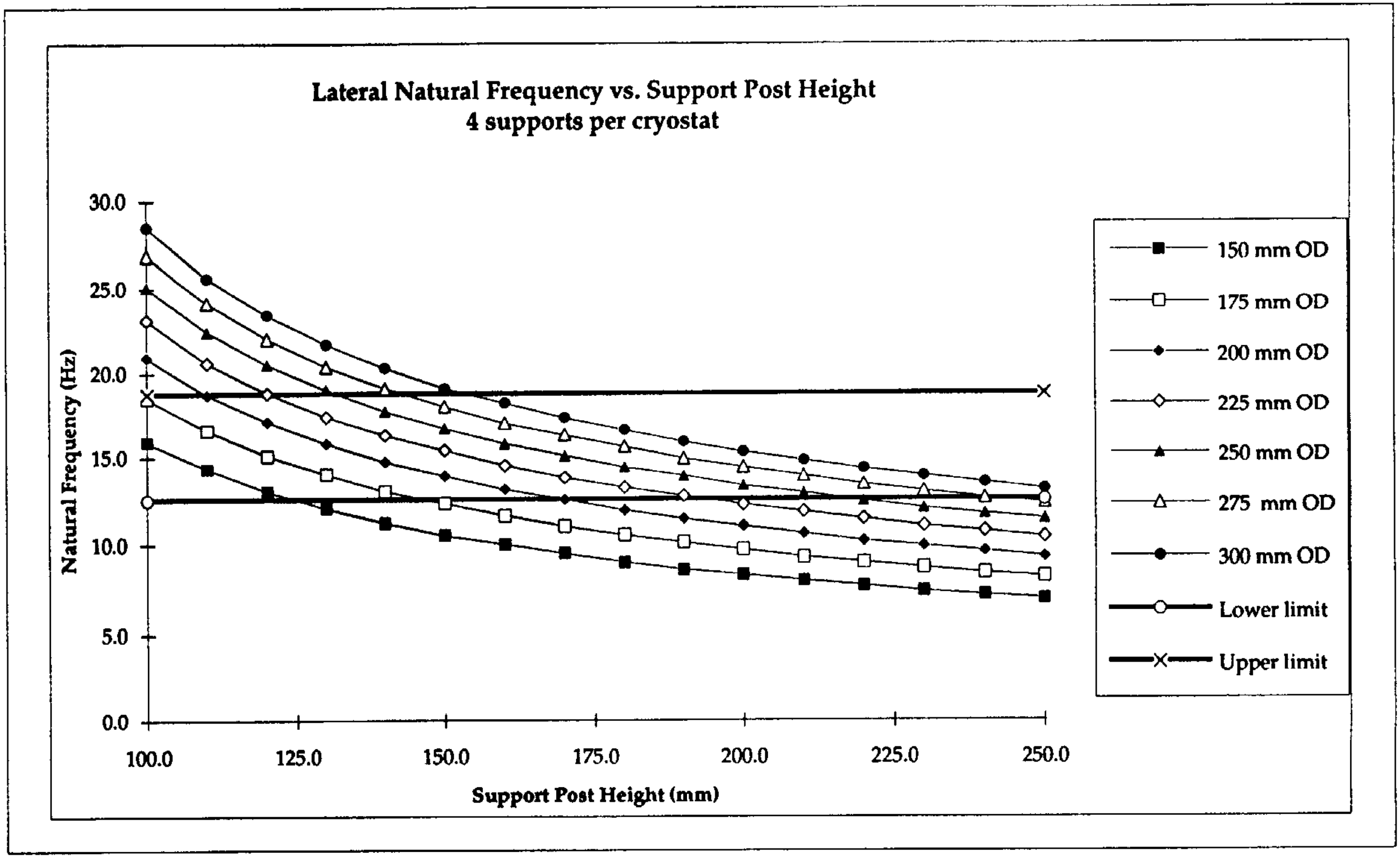


Figure B-5